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A Data Processing Module for Acoustic  
Doppler Current Meters

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Albert J. Plueddemann  
Andrea L. Olen  
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Stephen P. Smith

January 1992

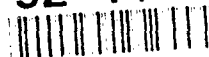
Technical Report

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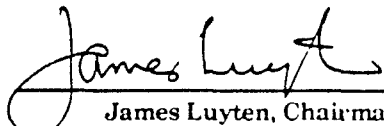
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## Abstract

This report describes the development of a Data Processing Module (DPM) designed for use with an RD Instruments Acoustic Doppler Current Meter (ADCM). The DPM is a self-powered unit in its own pressure case and its use requires no modification to the current meter. The motivation for this work was the desire for real-time monitoring and data transmission from an ADCM deployed at a remote site. The DPM serves as an interface between the ADCM and a satellite telemetry package consisting of a controller, an Argos Platform Transmit Terminal, and an antenna. The DPM accepts the data stream from the ADCM, processes the data, and sends out the processed data upon request from the telemetry controller. The output of the ADCM is processed by eliminating unnecessary data, combining quality control information into a small number of summary parameters, and averaging the remaining data in depth and time. For the implementation described here, eight data records of 719 bytes each, output from the ADCM at 15 minute intervals, were processed and averaged over 2 hr intervals to produce a 34 byte output array.



Keywords: Satellite telemetry, Acoustic Doppler Current Profiler, Argos.

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# 1 Introduction

## 1.1 Background and motivation

The desirability of data telemetry from remote, unmanned sites such as deep ocean buoys has been recognized for some time, and several programs at the Woods Hole Oceanographic Institution (Frye and Owens, 1991) and elsewhere have helped to develop this capability. Much of the work to date has concentrated on the telemetry of a limited set of data or status parameters, with little or no data processing or compression. Although more sophisticated systems are being developed (Frye and Owens, 1991; Irish *et al.*, 1991), in some cases the telemetered information from a complex sensor is only sufficient to provide an indication of instrument status. As instrumentation becomes more complex, and as information from multiple instruments is combined, the data rate exceeds that which can be transmitted via conventional means (e.g., Service Argos). By developing a telemetry interface module with data processing capability, it is possible to recover an intelligently composed subset of information from high data rate instrumentation systems deployed on a drifting or moored platform.

This report describes the development of a Data Processing Module (DPM) for use with acoustic Doppler current meters (ADCMs). ADCMs produce prodigious amounts of data in comparison to traditional oceanographic instrumentation like the meteorological sensors and single point current meters discussed by Frye and Owens (1991). During a deployment where a high degree of temporal and spatial resolution is required, the ADCM may generate as much as 1 Kbyte of data per min. Internal recording capacity of up to 40 Mbyte allows this data to be archived, but the low throughput of satellite telemetry systems like Argos (approximately 1 byte/min) make it impossible to transmit the complete data set. In order to be practical for real-time telemetry, the raw data must be

processed to create a reduced set of variables or data parameters to be transmitted.

An initial effort to obtain real-time data from an ADCM via satellite was guided by McPhaden at the Pacific Marine Environmental Laboratory (McPhaden *et al.*, 1990; 1991). The result was the PROTEUS mooring, consisting of a downward-looking ADCM mounted in the bridle of a surface buoy, and connected to a processor which transmitted averaged velocity profiles at 24 hr intervals. Although benefiting from their work, we felt that the design requirements (described below) were different enough to warrant a completely independent implementation. The PROTEUS mooring and the DPM are similar in that both provide an interface to the ADCM and do some pre-processing of ADCM data in preparation for satellite telemetry. The principal difference is that on the PROTEUS mooring one microprocessor handled both ADCM data processing and telemetry while the DPM processes the data and offloads it to an external telemetry controller. The design of the DPM as a self-contained, addressable module allows a telemetry controller to collect and transmit data from many different sensors by interrogating each in turn.

The development of the DPM was geared towards a particular initial application, an Arctic data buoy. A recent deployment of an Arctic Environmental Drifting Buoy (AEDB) developed by S. Honjo of WHOI (Honjo *et al.*, 1990) demonstrated the feasibility of a drifting buoy for making velocity and temperature measurements below the Arctic ice pack. The AEDB was deployed in August of 1987 in the pack ice north of Svalbard and drifted for 255 days while collecting data on ice and water temperature, subsurface currents, and particle fluxes. Although the prototype buoy was designed with telemetry capability, the data stream was restricted to buoy position, temperature, and various status

parameters. Information from the sub-surface instruments was not available until recovery.

A second-generation Arctic drifter, the Ice-Ocean Environmental Buoy (IOEB), has been developed to succeed the AEDB. The IOEB incorporates a new buoy hull design and a meteorological package in addition to sub-surface instrumentation similar to that deployed on the original buoy. Plans for the IOEB call for the data from both surface and sub-surface sensors to be made available to an Argos satellite transmitter housed in the surface floatation element. This strategy allows the status of the buoy to be monitored more closely during the deployment and will give immediate access to the data regardless of the fate of the drifter. Each IOEB will carry an ADCM, and both ADCMs will be equipped with a DPM to allow the sub-surface current data to be relayed via satellite to a shore based station along with surface meteorological data and buoy position. The purpose of the DPM is to serve as the interface between the ADCM and an Argos telemetry system on the IOEB and to provide a manageable subset of processed ADCM data for transmission.

## 1.2 Design requirements

The DPM packaging specification called for a self-powered, stand-alone unit in its own pressure case. In a typical deployment, the DPM would be attached to ADCM load cage (Fig. 1) or on the mooring line within a few meters of the ADCM. The power requirement was a battery supply sufficient for deployments of 6 to 9 months. Underwater cabling would provide the communications link between the ADCM and the DPM, and between the DPM and a telemetry controller. The communication requirements were set by the input and output devices; the DPM was designed to process ADCM data in a manner completely transparent to the instrument itself (i.e. requiring no modifications to the ADCM)

and to communicate with a generic telemetry controller using the software protocol associated with the Serial ASCII Instrumentation Loop (SAIL; IEEE, 1985).

From the point of view of the DPM there are three important characteristics of the ADCM: The communication protocol, the data stream, and the sample interval. For the application described here, the ADCM was configured to send a binary data stream via EIA-423 at 1200 baud (8 bits, no parity) every 15 minutes. The ADCM data stream, also known as an ensemble, consists of an average over a sequence of many acoustic pulses. For the IOEB application, individual pulses are transmitted once per second, with the data from 40 pulses making up one ensemble. At the end of each ensemble interval, the instrument records the data stream to EPROM memory and transmits the same data through the serial port. The sample interval and serial port enable are preset; the instrument sends out the data strings at fixed intervals based on its own clock and cannot be interrogated through the serial port while in the operational mode. The serial data stream contains a variety of configuration parameters in leader and header arrays, plus data arrays containing velocity, echo amplitude, and data quality information for each bin of each beam. Details of the characteristics of the RD Instruments self-contained ADCM are described in the manufacturer's documentation (RD Instruments, 1991a). A general familiarity with ADCM technical information, data formats, and terminology is assumed throughout this report.

For the application on the IOEB, the DPM was not to communicate directly to an Argos Platform Transmit Terminal (PTT), but rather to a telemetry system consisting of a controller, PTT, and antenna. The controller interrogates the DPM over an EIA-485 loop at 9600 baud using the SAIL software protocol (the SAIL/485 implementation is similar to that described by Park *et al.*, [1991]). Data requests from the controller are made once per hour. Upon receiving a valid SAIL address and a data offload command, the DPM echoes its address and then sends

an ASCII-Hex data stream to the controller. Since the timing between the ADCM, the DPM and the controller is arbitrary, the DPM must be able to service a SAIL data request at any time, even when actively communicating with the ADCM or processing data.

The difference in ADCM data output and Argos PTT throughput determines the required data reduction. The 719 byte data stream and 15 min ensemble interval chosen for the IOEB implementation give an effective data rate of about 3 kbytes/hr from the ADCM. The maximum throughput for Argos is in the range of 60 bytes/hr, giving a target for data reduction of at least a factor of 50. For the IOEB deployment, a throughput of only 17 bytes/hr was available for the ADCM data, so that data reduction by about a factor of 170 was necessary. A set of processing routines written in the C programming language, and used previously for laboratory analysis of ADCM data, was implemented on the DPM microcontroller for the purpose of data reduction.

Section two of this report provides a general description of the DPM, with the discussion separated into sub-sections on hardware, communication and control, and software. Four appendices provide more detailed information about the DPM and its use. Appendix A describes a procedure for testing the DPM in the lab and Appendix B describes the deployment procedure. Appendix C is a complete listing of all software used with the DPM. Appendix D provides technical information in the form of tables and figures.

## 2 Description of the DPM

### 2.1 Hardware implementation

The DPM hardware layout is sketched schematically in Figure 2. The heart of the electronics is an Intel 87C51FC microcontroller with 32k of external RAM.

an external, opto-isolated UART for EIA-423 communication with the ADCM, and an EIA-232 to EIA-485 converter for communication with a telemetry controller. A "watchdog" timer circuit implemented in hardware is used to reset the microcontroller in the event of firmware or communication errors. The power system consists of two battery packs and a switching regulator. The principal system components are discussed in turn below.

The Intel 87C51FC microcontroller was chosen for the DPM application for a number of reasons, the most significant of these being that all the necessary development tools were available to ensure that 'C' code for ADCM processing, developed for mini-computers, could easily be ported to the 87C51. In the addition to this the controller has many other desirable features such as: low power consumption, an idle mode, 32 kbytes of internal EPROM, 256 bytes of internal RAM, an internal UART, and 3 internal 16 bit timers. To keep power consumption low, the microcontroller is clocked by a 2.4576 MHz crystal and the UART crystal is 1.8432 MHz. As currently configured, the DPM uses approximately 23 kbytes of external RAM for data storage, so a 32 kbyte part was used. Since the microprocessor is running at a relatively low clock rate, a 150 ns, low power RAM was selected.

The external National Semiconductor NSC858 UART was selected because of its low power consumption and pin controllable power down mode. In this application the UART is left powered down for the majority of the time to conserve power. The port is set up to receive data only, and is shut down for 14 minutes of the 15 minute period between ADCM sampling intervals. This part was abruptly discontinued by National Semiconductor in early 1991; there is no pin-for-pin compatible replacement. Other similar UARTs are available, but their use would require both hardware and software modifications.

The DPM communicates with a telemetry controller via an EIA-485 link that uses SAIL software protocol. This was accomplished by using a Maxim RS-485 transceiver in conjunction with the microcontroller's internal UART. The Maxim part was selected because of its very low power consumption (1.3 mW typ.) and guaranteed EIA-485 performance. This part on the DPM is always enabled so that the module will respond to its SAIL address at any time.

The watchdog timer circuitry in the DPM is used to provide a power-up reset pulse and to reset the microcontroller if program execution fails. When power is initially applied to the DPM, pin 9 (reset) of the 87C51 is held high for approximately 100 ms, after which it is brought abruptly to ground. This provides the negative going edge (after the supply has stabilized) that is required to properly reset the microcontroller. The timing for the watchdog is generated by a low frequency R-C oscillator that is divided down to approximately 32 minutes (greater than two sampling periods for the ADCM). If the microcontroller does not regularly reset the clock divider, indicating a firmware error condition caused by either a lack of incoming ADCM data or a glitch in program execution, a power-up reset pulse will occur.

RD Instruments warns of a corrosion problem that occurs when ADCMs are used with an external serial device. To avoid this, the ADCM data lines must be electrically isolated from the external device. The design requirements of the DPM dictated use of a micro power isolator capable of data rates up to 9600 baud. A quick look at readily available off-the-shelf components (their power consumption in particular) led to the decision to build an isolator from discrete parts. A spectrally matched, high speed infra-red LED and photo diode were used in conjunction with a discrete current limiting circuit and a micro power operational amplifier to make the isolator. Tests showed that although the circuit could be made to operate at 9600 baud data rates, it was much more tolerant of

changes in the EIA-423 levels and to temperature fluctuations when biased for 1200 baud operation. An added advantage of this 1200 baud configuration was that the isolator performed well over such a wide range of signal levels that it could be driven directly from a serial port on a PC. Since high baud rates were not required to handle the 719 bytes of ADCM data at 15 minute intervals, the more robust and versatile 1200 baud configuration was implemented.

The DPM is equipped with two, 7 "D" cell alkaline battery packs. This provides a nominal 10.5 V source with a 28 ampere-hour capacity. De-rating the batteries to 66% of capacity to accommodate their degradation at low temperatures and to allow for some safety factor leaves the DPM with a working capacity of 18.5 ampere-hours. Design goals were to provide the DPM with a service life expectancy of approximately 9 months given the duty cycle appropriate for the IOEB deployment.

The function of the voltage regulator is to convert the battery voltage to a constant 5 volt supply for the DPM. The Maxim MAX638EPA switching regulator was chosen for its high conversion efficiency and small size (low associated parts count). Bench tests showed that the configuration used in the DPM would function at 75% to 92% efficiency over the full range of expected operating conditions. The wide range of efficiency is due to load conditions that vary from 2-30 mA, and from an input (battery) voltage range that varies from 11-6.5 V (6.5 is the minimum input voltage allowed for regulator operation).

## **2.2 Communication and control**

The DPM communicates serially with the ADCM over an optically isolated EIA-423 link and with a telemetry controller via EIA-485. The 1200 baud EIA-423 communications link is accomplished in the DPM by an NSC858 UART which provides a data ready pulse to the 87C51 microcontroller's external

interrupt 1 pin. The 87C51 on-chip serial port services the 9600 baud EIA-485 communication link. Both channels use 8 bits and no parity.

A flow chart of DPM communication and control is shown in Figure 3. The DPM is initially powered up by use of an external control line (a shorting plug) or may experience a power-up reset due to the watchdog timer. In normal operation the DPM resets the watchdog timer every 15 minutes, after receipt of each ensemble from the ADCM. This prevents the timer from reaching its 32 minute trigger. In the event that the timer is not reset during a 32 minute period, the watchdog circuit will provide a pulse to reset the DPM. Upon reset, the DPM restarts the firmware, reinitializing all variables and zeroing the output buffers. Thus, a data stream of all zeros from the DPM in response to a SAIL query indicates that a reset has occurred.

In order to save power, the 87C51FC microcontroller is put into a low power idle mode whenever it is not processing data or servicing serial, external or timer interrupts. The microcontroller exits idle mode when it receives an interrupt, so the telemetry controller can address the DPM over the EIA-485 link at any time. The NSC858 UART is turned off by the microcontroller directly after receipt of a complete 719 byte ensemble from the ADCM. While it is off, characters sent by the ADCM would not trigger an external interrupt and therefore not be received by the DPM. However, the UART is turned back on 14 minutes after it is turned off, in response to the microcontroller's internal timer 1 interrupt routine. Since ensembles are sent every 15 minutes by the ADCM, all of the ADCM data is received.

A communications interrupt may be either the EIA-423 data stream from the ADCM or an EIA-485 SAIL command from a telemetry controller. If incoming ADCM data has the proper character count (719 bytes), it is sent to an "unpacking" routine where the packed binary data stream is decoded. An

incomplete ensemble (at least 1 byte, but less than 719 bytes) causes a timeout in the communications routine and is counted as a bad ensemble. Ensembles sent to the unpacking routine which do not have the correct checksum, or do not contain the expected header values, are rejected and counted as bad ensembles. Otherwise, the "good ensemble" counter is incremented and the data is stored for later processing.

When the total number of ensembles received (the sum of the good and bad ensemble counters) equals eight, representing two hours of data from the ADCM, the DPM processes the data and stores a 68 character ASCII-Hex data array in one of two output buffers for transmission to the telemetry controller. The double buffering scheme is used to ensure that an existing output array, which has not yet been sent to the controller, will not be corrupted by newly processed data. Within each buffer the output array is arranged in two halves, an "even half" containing data for the even depth bins of the ADCM profile, and an "odd half" containing data for the odd depth bins (the details of the output array contents are discussed in Section 2.3).

Two telemetry controllers, with independent PTTs and Argos antennae, are used on the IOEB to provide a robust data transmission scheme. Each controller interrogates the DPM at 2 hour intervals, but their timing is staggered so that the DPM receives a request for data approximately once per hour. A SAIL data request consists of an attention character (#), a two character address, and a data offload command (R). The DPM responds to a data request with an echo of the address and offload command followed by 34 ASCII-Hex characters of data from the most recently filled output buffer. The two controllers use different addresses (40 and 41) to interrogate the DPM. The DPM considers either of the two addresses valid, sending the even half of the output array in response to a data request which uses the even address (#40R) and the odd half in response to one

which uses the odd address (#41R). Thus, transmission of the full DPM output array is split over two independent telemetry systems. The data in the two halves of the output array are arranged so that either half alone provides useful information.

## 2.3 Data processing

The DPM processing routines were developed from programs used to analyze ADCM data from the Arctic Environmental Drifting Buoy deployment (Plueddemann, 1991). There are two principal processing tasks, "unpacking" the binary ADCM data stream for each ensemble and reducing the data after eight ensembles have been unpacked. For the IOEB application the ADCM data stream is 719 bytes long and contains a header and leader, plus velocity, echo intensity, percent good, and status information for each beam (Fig. 4). Spectral width is not recorded. The unpacking step consists of decoding the packed binary ADCM data stream and filling a floating point array with the decoded, scaled data. The majority of the data reduction is accomplished by eliminating non-essential data and averaging the remaining data in depth and time. Some additional benefit is gained from the creation of summary error and status parameters and judicious scaling based on expected data values.

Upon receiving a 719 byte ensemble from the ADCM, the controlling program passes the array to the unpacking routine. The first step in the unpacking routine is to compute the checksum for the complete ensemble and decode the header. The checksum computed in the unpack routine is compared to the checksum sent with the ensemble. The size of each of the data arrays is extracted from the header (Fig. 5) and checked against the expected array sizes. Any errors found during these checks result in a flag being set to indicate a communication error. The associated data ensemble is counted as a "bad ensemble", it is not stored and

will not be included in the averaging step. Ensembles which pass these checks are processed further; the leader data (Fig. 6) is extracted and stored (except for the CTD and bottom track variables, since these functions are not used), and the four data arrays are decoded and stored.

After eight ADCM ensembles have been received, the controlling program calls a sequence of routines that perform several processing steps along with error checking and averaging. The first processing step is to document the status of ADCM operation using information from the leader and the percent good array. The Built In Test (BIT status; RDI, 1991a) code from the leader is used to set two flags, one for beam frequency errors and one for transmitter current errors. The percent good information is combined into a single good/no-good status bit for each averaged bin. Data in a given bin is generally considered to be of poor quality if the percent good value is less than 25. The status bit is set if percent good values less than 25 occur in more than ten percent of the samples in the depth-time averaging interval.

The next processing step is time averaging of the leader data. This consists of a simple arithmetic average over the number of unpacked ensembles in the storage arrays. Under normal conditions 8 ensembles will have been unpacked and stored at the end of a two hour period. If communication errors have occurred, there may be fewer than 8 ensembles to process. There are 14 leader values included in the averaging step: time in decimal days, number of ADCM bins, ensemble number, BIT status, x-axis tilt, y-axis tilt, heading, temperature, high voltage level, transmit current level, low voltage level, and the standard deviations of x-tilt, y-tilt, and heading.

The major processing task involves manipulation of the velocity and echo amplitude data, recorded by the ADCM in beam coordinates, to produce depth-time averaged arrays in earth coordinates. For the IOEB application a 16 m

transmit pulse was used and 40 eight-meter bins were recorded. Note that since the transmit pulse sets the fundamental vertical resolution of the measurements, the eight meter bins represent oversampling by a factor of two. The depth averaging implemented for the IOEB deployment is a three bin average of the first 30 bins, resulting in 10 averaged bins. Time averaging is over the 2 hr interval represented by the sequence of 8 ensembles. Before the averaging step, however, several other processing tasks are executed. First, the tilt data is used to interpolate the slant velocity and echo amplitude for each beam onto standard depths. Next, the four beams of slant velocity are combined into two horizontal velocities and two vertical velocity estimates. The heading data is used to rotate the horizontal velocities into earth coordinates. The mean of the two vertical velocities and the mean of the four beams of echo amplitude are computed during the averaging. Thus, the output of this processing step is 4 ten-bin arrays containing depth-time averaged values of east velocity, north velocity, vertical velocity, and echo amplitude.

The final step in the processing is to pack the status flags plus the averaged leader and velocity data into an output buffer for transmission to a telemetry controller. As discussed above, there are two telemetry controllers on the IOEB which request data from the DPM using two different SAIL addresses. Between the two controllers the DPM is interrogated once per hour and the full output array, representing a two hour average, is sent in two halves. It was decided that the hourly transmissions would consist of a header plus status and velocity data for half of the depth bins. The header is repeated for each transmission, but alternating even and odd depth bins are sent in response to the alternating SAIL addresses. A combination of a count bit which alternates between 0 and 1, and an even (0) and odd (1) bin flag are used to keep track of what has been sent (i.e., four successive transmissions would have a [count, even/odd bin] sequence of

[0,0] [0,1] [1,0] [1,1]). This information is useful for putting the half-arrays back together in the proper order, particularly if occasional transmissions are missed. The repeated header and alternating even-odd bin sequence is similar to the scheme described by McPhaden *et al.* (1990) and ensures that usable data spanning the desired depths (albeit with poorer resolution) will be received even if one of the telemetry systems malfunctions.

Due to the limited space (135 bits) allotted to the ADCM for each hourly transmission from the IOEB (Fig. 7), the averaged data had to be reduced further before going into the output buffer. This was accomplished by choosing not to transmit the echo amplitude array and restricting the output header to a subset of the averaged leader data. The floating point horizontal velocity data is scaled and converted into 8-bit integers, the vertical velocity into 4-bits. The first half of the 272 bit output array (Fig. 8) consists of a dummy bit, count bit, even/odd bin bit, even-bin status array (5 bits), error flag array (4 bits), temperature (8 bits), number of ensembles in the average (4 bits), tilt standard deviation (6 bits), heading standard deviation (6 bits), even-bin east velocity array (40 bits), even-bin north velocity (40 bits), and even-bin vertical velocity (20 bits). The second half of the output array (Fig. 8) contains the same count bit, the opposite even/odd bin bit, the same error, temperature, ensemble, and instrument motion data, and the odd-bin status, east velocity, north velocity, and vertical velocity arrays.

The output data is packed into an ASCII-Hex array with two characters per 8-bit word. Thus, it takes 272 bits to store the 68 ASCII-Hex characters. A pointer, set by examining the incoming SAIL address, determines whether the even or odd half of the buffer will be sent to the telemetry controller each hour. Upon receipt by the controller, the 34 ASCII-Hex characters are unpacked, the dummy bit is eliminated, and the remaining 135 bits are added to the data stream for the appropriate PTT (Fig 7).

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## References

- Frye, D. E. and W. B. Owens, 1991. Recent developments in ocean data telemetry at Woods Hole Oceanographic Institution, *IEEE Journal of Oceanic Engineering*, 16(4), 350-359.
- Honjo, S., R. Krishfield and A. Plueddemann, 1990. The Arctic Environmental Drifting Buoy (AEDB): Report of field operations and results, Woods Hole Oceanographic Institution, Woods Hole, MA, Technical Report WHOI-90-2, 128 pp.
- IEEE Computer Society, 1985. IEEE standard serial ASCII instrumentation loop (SAIL) shipboard data communication, IEEE, New York.
- Irish, J. D., K. E. Morey, G. J. Needell and J. D. Wood, 1991. A current meter with intelligent data system, environmental sensors, and telemetry, *IEEE Journal of Oceanic Engineering*, 16(4), 319-328.
- McPhaden, M. J., H. B. Milburn, A. I. Nakamura and A. J. Shepherd, 1990. PROTEUS - Profile Telemetry of Upper Ocean Currents, *Proc. MTS 1990 Conference, Marine Technological Society*, 353-357.
- McPhaden, M. J., H. B. Milburn, A. I. Nakamura and A. J. Shepherd, 1991. PROTEUS - Profile Telemetry of Upper Ocean Currents, *Sea Technology*, February Issue, 10-19.
- Park, M. M., R. C. Singer, A. J. Plueddemann and R. A. Weller, 1991. High-speed, real-time data acquisition for vector measuring current meters, *IEEE Journal of Oceanic Engineering*, 16(4), 360-367.
- Plueddemann, A. J., 1991. Internal wave observations from the Arctic Environmental Drifting Buoy, *Journal of Geophysical Research*, submitted.
- RD Instruments, 1991a. Self-Contained Acoustic Doppler Profiler Technical Manual, RD Instruments, San Diego, CA, 330 pp.
- RD Instruments, 1991b. Deployment Program User's Manual, RD Instruments, San Diego, CA, 34 pp.

## Appendices

### A. Test procedure

A test procedure meant to be used in verifying the operation of the DPM prior to field deployment is described below. Two IBM compatible PCs, an ammeter, and various test cables are necessary for the complete test (Fig. 9). The ammeter replaces the DPM shorting plug and is used to check current draw by the UART and microcontroller. The procedure can be performed without the ammeter if current checks are not desired. The PCs simulate the ADCM and telemetry controller. The result of the test is a sequence of DPM output records which can be compared to a file containing the expected output. A RMK-7 to DB-25 test cable is needed to connect the EIA-423 side of the DPM to the PC simulating the ADCM. A program called OVERNITE.C (see Appendix C) is run on this PC to send simulated ADCM data transmissions to the DPM. The program accesses a data file called DPMCCS6.BIN containing a sequence of previously recorded ADCM binary data ensembles which have been modified to test a variety of DPM features. A RMG-3BCL connector and cable are used to connect the EIA-485 side of the DPM to an Acromag EIA-485 to EIA-232 converter box. A second cable with two DB-25 connectors attaches the Acromag box to the serial port (COM1) of the PC simulating the telemetry controller. This PC runs a program called TT.C (see Appendix C) which requests processed data records from the DPM using SAIL commands.

The VSG-2BCL connector on the top end cap of the DPM is used to power the module. A dummy plug is used to cover this connector when the DPM is not in use. The RED color-coded shorting plug turns the DPM on by connecting the 10.5 VDC battery packs in the DPM to the input of the switching regulator. After making the initial connection with an ammeter in place of the shorting plug, the

DPM should settle out, within 20 seconds, to a current drain of  $2.3 \text{ mA} \pm 0.3 \text{ mA}$ . At this point the DPM UART is on and waiting for data. The DPM will stay in this state until it receives a serial stream from the ADCM (or equivalent simulation). The ADCM serial data enters the DPM via the XSK-7BCL connector. The XSG-3BCL connector is the EIA-485 connection between the DPM and the telemetry controller or controller simulator.

ADCM operation is simulated by connecting the RMK-7 to DB-25 test cable from the DPM to the serial port (COM1) of a PC and running the test program OVERNITE.C. The test program will ask for a data file to use as input. The file DPMCCS6.BIN should be available in the same directory as OVERNITE.C and should be specified as the input file. The number of ensembles should be set to 144 and the time between ensembles to 15 minutes. If a mistake is made in specifying input parameters for OVERNITE.C, reboot the computer, reset the DPM by removing and re-connecting the shorting plug (or ammeter connection), and start again. When OVERNITE.C is running successfully, a message will be sent to the screen as each simulated ADCM data ensemble is sent.

Immediately after receiving a valid ADCM data ensemble, the current draw from the DPM will rise to  $5.5 \text{ mA} \pm 0.5 \text{ mA}$  for a few seconds while the DPM unpacks and stores the data in RAM. After receiving and unpacking the data, the DPM goes into an idle mode in which it will respond to EIA-485 SAIL requests from the telemetry controller, but will not accept data from the ADCM. The NSC858 UART is powered down in this state and the microcontroller is idle. The current drawn by the DPM will drop to  $1.2 \text{ mA} \pm 0.3 \text{ mA}$ . The idle mode will continue for 14 minutes after which the UART is turned back on and the DPM is ready and waiting for EIA-423 data from the ADCM. The current level will increase back to the original  $2.3 \text{ mA} \pm 0.3 \text{ mA}$  until another valid ADCM ensemble is received and the data collection cycle begins again. This cycle will

continue unless data is not received from the DPM at the expected 15 minute interval (e.g., the ADCM is disconnected or inoperative and data transmissions stop). If no ADCM ensembles are received, the DPM will wait in the ready state (NSC858 UART on) for EIA-423 data and the microprocessor will be reset every 32 minutes by the watchdog timer.

Any time after the DPM is turned on (using the shorting plug or an ammeter in place of the shorting plug), the module can be addressed via EIA-485 SAIL commands. A 50 foot test cable with a RMG-3BCL connector on one end is provided for this purpose. The other end of the cable should be connected to an Acromag 485/232 converter box. The EIA-232 side of the Acromag box is then connected to the serial port (COM1) of a PC running the telemetry controller simulation program TT.C. (Note that TT.C is not necessary for a simple simulation of the telemetry controller — a terminal emulation program running on the PC with serial communication settings of 9600 baud, no parity, 8 data bits, 1 stop bit can be used to send SAIL commands by hand). It should be started at least 5 minutes, but less than 15 minutes after OVERNIGHT.C for proper results. The TT.C program will request a data file name to which it will log the DPM responses. TT.C will send the first command (without the attention character #) to the DPM within a minute after the interrogation loop is started by selecting a transmission interval. An interval of 60 minutes should be selected. The DPM will respond to the SAIL data offload commands #40R and #41R with an echo of the command (without the attention character #) followed by 34 characters of data and an ETX (ASCII 03) to end the transmission. The data will be all zeros until eight ensembles have been received and processed. The receipt of eight ensembles will take two hours from the time of the first ADCM ensemble. Since the DPM output array is in two halves, transmitted once per hour, the response to the first two SAIL requests will contain zeros.

The processing steps initiated upon receipt of the 8th ADCM ensemble take approximately four minutes to complete. During this time the current drain at the DPM will be  $6 \text{ mA} \pm 0.5 \text{ mA}$ . Once the first set of eight ensembles has been processed, the DPM will respond to the SAIL offload commands by sending the processed data. If at any time after this the DPM responds to a data request with a string of zeros, it is an indication that the microprocessor has been reset by the watchdog timer. A listing of the expected DPM output when using the simulated ADCM ensembles in the file DPMCCS6.BIN is given in Figure 10 and in the file DPMCCS6.OUT. The contents of the file created by TT.C during the test procedure should be compared to this listing.

## B. Deployment procedure

1. The ADCM and DPM should be installed in the load cage (see Fig. 1) and the cable from the telemetry controller should be accessible at the location of the DPM.
2. Download the desired configuration parameters to the ADCM using the Deployment Configuration Files provided (e.g., I198.DPF) and the RD Instruments Deployment Program (RD Instruments, 1991b). Upon completion of the deployment procedure, the ADCM will be running and sending serial data every 15 minutes. The first ensemble will be sent immediately following the last entry in the deployment sequence. Since the DPM is not connected at this time, the first ensemble received by the DPM will be 15 minutes later.
3. Remove the three dummy plugs from the DPM and store them in the packing crate. Locate the RED color-coded shorting plug in the packing crate. Attach the DPM XSK-7BCL connector to the ADCM XSL-20BCR

I/O connector using the two meter RMK-7FS to XSL-20CCP cable packed with the DPM. Attach the DPM XSG-3BCL connector to the telemetry controller cable.

4. Power up and reset the DPM by connecting the RED color-coded shorting plug to the VSG-2BCL connector on the end cap. The DPM will now be running and waiting for the next ensemble from the ADCM. Note that the first ensemble will not have been received by the DPM (see (2)), but it is assumed that (3) and (4) are completed within 15 min of starting the ADCM, so that the second ensemble will be received.
5. The DPM can be interrogated by the telemetry controller at any time after power-up. The first non-zero data array from the DPM will be obtained after receipt and processing of eight ADCM ensembles, or 2 hrs after receipt of the first ensemble. Since the first ADCM record is not received by the DPM, this will occur approximately 2 hrs 15 min after start-up of the ADCM.

## C. Program listings

Four C-language programs associated with the use of the DPM are listed on the following pages.

DPM.C is the main communication and processing program, written in Franklin C, which runs on the Intel 87C51FC microcontroller in the DPM. The compiler used was Franklin C, version 3.07, the assembler was Franklin Assembler version 4.4, and the linker was Franklin Linker L51, version 2.7. A companion program, PC.DPM.C, was written in Microsoft Quick-C and run on an IBM compatible PC. PC.DPM processes data in the same fashion as DPM.C, but reads from and writes to disk files on the PC rather than communicating to the ADCM

or the telemetry controller. This version was used during development and testing, but is not reproduced here.

OVERNITE.C and TT.C are used in the deployment simulation procedure and allow the DPM to be exercised in the absence of the other instrumentation to be used in the deployment. OVERNITE.C simulates the operation of the ADCM by taking a file of binary ADCM data and sending it serially to the DPM at a user specified interval. TT.C simulates the telemetry controller by sending alternating SAIL data offload commands (#40R and #41R) to the DPM at an adjustable interval. The data received in response is stored in a file and printed to the screen.

DPMSATOUT.C unpacks the output data array sent to the telemetry controller, and was used during development and testing of the DPM. The program takes groups of 34 ASCII hex characters representing alternating halves of the output data array, combines the appropriate pairs, and then decodes the data.

```

/* DPM.C
 * by Robin Singer
 * May 1, 1991
 *
 * Franklin C compiler version 3.07
 * Franklin Assembler version 4.4
 * Franklin Linker (L33) version 2.7
 *
 * Main routine for ADCP DPM
 *
 * The DPM is a data processing module which processes ADCP
 * ensembles and provides an ASCII Hex string in response to
 * a SAIL request over an EIA-485 channel. It runs on an
 * Intel 87C31FC microcontroller with 32K of external RAM,
 * an MSC 858 UART for EIA-422 communication with the ADCP,
 * a 32 minute hardware deadman timer, and an EIA-485 con-
 * troller on the microcontroller's serial lines. Double
 * buffering is used and odd and even layer data is sent in
 * response to different SAIL addresses. The microcontroller
 * is clocked by a 2.4576MHz crystal and the UART crystal is
 * 1.8432MHz.
 *
 * The terms record and ensemble are used interchangeably
 *
 * #define TRUE 1
 * #define FALSE 0
 * #define MAXBYTE 255
 * #define ENSEMBLE 1
 * #define UART 0
 * #define MCEAM 4
 * #define BRECA 8
 *
 * #define MAXBINS 40 // number of bins per record
 * #define MAXLDR 14 // max # of leader to store
 * #define MAXEPS 10 // max. no. of ensembles to store
 * #define AVGCLA 14 // # of points in averaged leader
 * #define AVGCRP 10 // # of depth bins after averaging
 * #define MTYPE 22 // # of data types (leader+ensemble)
 *
 * #include <reg31f.h>
 * #include <math.h>
 *
 * bit attention, addressed, offload, oddaven, intacht, nosleep; /* flags */
 * bit tltang, tltang, altflag, acflag, bufbit, digl;
 * unsigned char data[MAXBYTE], * data_dptr; /* incoming ADCP data buffers/per */
 * unsigned char nproc; /* count of good adcp data ensembles sent */
 * unsigned char ncount; /* count of ASCII hex chars to send via SAIL */
 * unsigned char unp_err; /* number of errors from unpack routine */
 * unsigned char badrec; /* number of short or bad records */
 * unsigned char * outbuff, * outbuff2; /* wait for count timer 1 iterations */
 * char * outbuff, * outbuff2, * outbuff3; /* processed data output buffers/per */
 *
 * /* declaration of arrays and structures */
 *
 * typedef struct stored /* unpacked data structure */
 {
 float ldr[MAXLDR]; /* subset of leader data */
 float vel[NHEAM][MAXBINS]; /* velocity array */
 }

```

```

float amp[NHEAM][MAXBINS]; /* echo amplitude array */
float qd[NHEAM][MAXBINS]; /* percent good array */
unsigned char at[NHEAM][MAXBINS]; /* bit status array */
} stored;

stored stor[NHEAM]; /* array of structures of unpacked data */

typedef struct averaged /* record-averaged data structure */
{
 float ldr[AVGCLA];
 float jnt[1][AVGCRP];
 float amp[AVGCRP];
 unsigned char abt[AVGCRP];
 unsigned char error;
 averaged avg;
} averaged;

extern void ADINIT(void);
extern void MCEAM(void);
extern void checkaddr(void);
extern void sendpt(char * buff, char * tbuf);
extern void process(char * fmbuff, char * tbuf);
extern void goodnight(void);
extern void ttdelay(void);
extern void wondle(void);
extern void aclock(void);
extern void etimer(void);
extern void unp_1(unsigned char lrec, unsigned char *e);
extern void pc_leader(unsigned char arec);
extern void repack(unsigned char *bptr, bit count, unsigned char arp);
extern void warton(void);
extern void err(unsigned char arec);
extern void notdead(void);
extern void prepack(unsigned char *bptr);

main()
{
 attention = FALSE; /* initialize SAIL bit flags */
 addressed = FALSE;
 offload = FALSE;
 nosleep = FALSE; /* sleep after loop unless partial record timeout */
 tltang = TRUE; /* start out with UART enabled */
 tltang = FALSE; /* haven't used timer 1 for ensemble time yet */
 oddaven = 0; /* point to start of data buffer */
 adptr = &data; /* initialize number of strings from adcp */
 nproc = 0; /* last time send from buffer, repeat this buffer */
 bufbit = 0; /* initialize bad record counter */
 badrec = 0; /* initialize global error flag */
 avg_err = 0; /* initialize unpack error indicator */
 unp_err = 0; /* initialize UART */
 ADINIT(); /* initialize 8751 serial communication */
 MCEAM(); /* zero the ASCII hex output buffers */
 prepack(buf); /* initialize the deadman timer */
 prepack(buf); /* set up buffers to echo address and offload cmd */
 buf[0] = 0;
 buf[1] = 0;
}

```

[illegible]

```

/* dmafee.c */
/* by Robin Sloger */
/* May 15, 1991 */

/* Franklin C compiler version 3.07 */
/* Franklin Assembler version 4.4 */
/* Franklin linker (l31) version 2.3 */

extern data int tcount; /* iteration counter for UART sleep interval */
extern int tcount; /* iteration counter for assembler receive timer */
extern unsigned char * data_dgptr;
extern unsigned char data[];

#define TRUE 1
#define FALSE 0
#define PDLAY 100 /* power down delay to wait for stop bit */
#define DMDLAY 450 /* deadman timer reset delay */
#define DMUFFLEN 36 /* length of RX output data string */
#define UOM - 0x01; /* MSC UART on pin */
#define DEADMAN - 0x90; /* Deadman timer (4040) Reset line */

#include <reg31.h>
#include <math.h>

/* power down BSC and then put 8751 into idle mode */
void goodnight(void)
{
    unsigned char n;

    for(n=0;n<PDLAY;n++) /* delay a bit */
        UOM = FALSE; /* power down the uart by clearing 87.1 */
    dgptr = data; /* when we wake up we will be ready for a new ensemble */
    TCOM |= 0x01; /* go into idle */

    /* power down BSC but leave 8751 on */
    void uttactff(void)
    {
        unsigned char n;

        for(n=0;n<PDLAY;n++)
            UOM = FALSE;

        /* leave UART on but put micro into idle */
        void wondle(void)
        {
            unsigned char n;

            for(n=0;n<PDLAY;n++) /* delay a bit */

```

```

        TCOM |= 0x01; /* go into idle */

        /* UART alarm clock routine */
        /* sets up the timer to wake up the BSC UART in time to listen */
        /* for the next ADCP ensemble */
        /* also used for timeout clock in case a partial ensemble or */
        /* array characters arrive at the UART */

        void aclock(void)
        {
            TCOM = 0x10; /* timer 1 to timer mode 1 (16 bits) */
            TLI = 0x00; /* 16 bits at 2.4M gives .3 sec */
            TCOM |= 0x01; /* set the timer 1 run control bit to turn timer 1 on */
            itcount = 0; /* enable timer 1 interrupt */

            /* The timer 1 ISR (intrtimc.031) will increment itcount and reset the */
            /* timer unless: (1) acflag equals 0 and 255 iterations (14 minutes) */
            /* has passed, in which case it turns the uart on and sets the clearing */
            /* flag to TRUE... or... (2) acflag equals 1 and 144 iterations (about */
            /* 40 seconds) have passed in which case it sets the clearing flag. */

            void notdead(void) /* prevents hardware reset by resetting 4040 */
            {
                int delay;

                DEADMAN = 1; /* send reset to deadman circuit (4040) */
                for(delay=DMUFFLEN; delay>0; delay--)
                    DEADMAN = 0; /* end of deadman reset pulse */

                /* Initialize output buffers with null echo and zeros */
                void prepact(unsigned char *bufptr)
                {
                    unsigned char n;

                    *bufptr++ = '4';
                    *bufptr++ = '0';
                    *bufptr++ = '4';
                    for(n=0;n<DMUFFLEN;n++)
                        *bufptr++ = 0x30;
                    *bufptr++ = '4';
                    *bufptr++ = '1';
                    *bufptr++ = '8';
                    for(n=0;n<DMUFFLEN;n++)
                        *bufptr++ = 0x30;
                }
            }

```

```

/*
  dspace.h
  This header file contains symbolic constants and external data
  structure declarations that are used in the functions called by
  the dspace/dpm program.
*/

#define MAXBYTE 719 /* max number of bytes per record(serial input)*/
#define MECA 8 /* number of records to accumulate */
#define MAXBINS 40 /* number of depth bins per record */
#define MAXLDR 14 /* number of values of leader to store */
#define MAXLDR 4 /* number of sonar beams used in calc */
#define AVGCLR 14 /* number of leader values averaged and stored */
#define AVGCLNS 18 /* number of depth bins after averaging */
#define MSMA 3 /* no. of bins averaged(MAXBINS div. by AVGCLNS)*/
/* for dt and ds functions */
#define NTYPE 22 /* no. of data types(leader,velocity,amplitude)*/
#define IO_FACTOR 3 /* multiple of standard dev. for threshold set */

extern unsigned char ddata[MAXBYTE]; /* input data buffer */

typedef struct stored /* stored data structure */
{
    float ldr[MAXLDR]; /* subset of leader .etc */
    float vel[MHEAM][MAXBINS]; /* velocity array */
    float amp[MHEAM][MAXBINS]; /* echo amplitude array */
    float qd[MHEAM][MAXBINS]; /* percent good array */
    unsigned char st[16][MAXBINS]; /* bit status array */
} stored;

typedef struct averaged /*struct of data averaged over MECA # of records*/
{
    float ldr[AVGCLR]; /* averaged leader array */
    float len[1][AVGCLNS]; /* averaged Janus velocity array */
    float amp[AVGCLNS]; /* averaged echo amplitude array */
    unsigned char ab[AVGCLNS]; /* calc status using percent good */
    unsigned char error; /* error code per output cycle */
} averaged;

extern stored stor[MECA]; /* array of unpacted records */
extern averaged avq; /* averaged data array */
extern float dt_thresh[NTYPE]; /* dt threshold storage buffer */
extern float ds_thresh[2*MHEAM]; /* ds threshold storage buffer */
extern float eab[4][10]; /* beam and bin averaged echo amp */

```





```

    %s = 1;
    if (%s > 0)
    {
        if ( (Out & avg_error) == 0 )
            avg_error = avg_error + 4;
        return;
    }

/* unpack leader */
dec_long(lrec)

if (nbin != MAXBINS)
    %s = MAXBINS;
    avg_error = 0.00;

/* loop through depth bins unpacking velocity, echo amp,
 * percent good flags, and status */
for (i = 0; i < nbin; i++)
{
    /* compute byte locations for this bin */
    j = (i*4) /* velocity, 4 bytes per bin */
    k = (i*4) /* echo amplitude, 4 bytes per bin */
    l = (i*4) /* percent good, 4 bytes per bin */
    m = (i*4) /* status, 2 bytes per bin */
    n = (i*4) /* spectral width, 4 bytes per bin */
    o = (i*4) /* spectral width, 4 bytes per bin */

/* unpack velocity (cm/s) */
    splitb(ddata[m], 4, 1, 1, 1);
    stor(lrec).val[0][i] =
        VEL_SC * signb(combn(m_LO, ddata[j], 1, 1));
    splitb(ddata[k], 4, 1, 1, 1);
    stor(lrec).val[1][i] =
        VEL_SC * signb(combn(m_LO, ddata[j+1], 1, 1));
    splitb(ddata[l], 4, 1, 1, 1);
    stor(lrec).val[2][i] =
        VEL_SC * signb(combn(m_LO, ddata[j+2], 1, 1));
    splitb(ddata[m], 4, 1, 1, 1);
    stor(lrec).val[3][i] =
        VEL_SC * signb(combn(m_LO, ddata[j+3], 1, 1));

/* unpack echo amplitude (dB) */
    for (lbeam = 0; lbeam < 4; lbeam++)
    {
        stor(lrec).amp[lbeam][i] =
            AMP_DB * comb(ifl60, ddata[k+lbeam]);
    }

/* function dec_long
 * decodes the long leader (63 bytes) */
}

```

```

void dec_long(unsigned char lrec)
/* lrec is the storage buffer record index */

{
    unsigned int i; /* byte location for beginning of leader 333 */
    unsigned char j; /* j < lead_as (63) */
    /* loop through leader bytes (index 3) */
    for (j = 1; j < lead_as; j++) { /* 33 lead_as not visible 333 */
        /* offset to proper byte location in ddata (index 1) */
        i = j + 8192_818 - 1;
        switch (i)
        {
            case 1: /* data */
                /* get mo, dy, hr, min, sec from ddata buffer */
                sprintf(month, "%02.2s", ddata[i]);
                sprintf(day, "%02.2s", ddata[i+1]);
                sprintf(hour, "%02.2s", ddata[i+2]);
                sprintf(minute, "%02.2s", ddata[i+3]);
                sprintf(second, "%02.2s", ddata[i+4]);
                /* compute date in decimal julian days */
                julday = julian(atol(month), atol(day), atol(year));
                dtime = atol(hour)/H
                    + atol(minute)/M*H
                    + atol(second)/M*M*H;
                date = dtime + julday + oidy;
                /* check for new year */
                if (oidyear == 0)
                {
                    if (strcmp(month, "12") == 0)
                        oidy = julday;
                }
                break;
            case 6: /* time between pings (decimal seconds) */
                sprintf(minute, "%02.2s", ddata[i]);
                sprintf(second, "%02.2s", ddata[i+1]);
                sprintf(hour, "%02.2s", ddata[i+2]);
                time = atol(minute)*60
                    + atol(second);
                break;
            case 9: /* pings per ensemble */
                ping = comb(ddata[i], ddata[i+1]);
                break;
            case 11: /* bins per ping */
                nbins = comb(2ER08, ddata[i]);
                break;
            case 12: /* bin length (meters) */
                lns = comb(2ER08, ddata[i]);
                if (lns > 5) lns = 0;
                blen = pow((double)2.0, (double)lns);
        }
    }
}

/* fill the storage array with desired leader variables */
break;
case 13: /* transmit interval (meters) */
    time = comb(2ER08, ddata[i]);
    break;
case 14: /* delay after transmit (nearest meter) */
    delay = comb(2ER08, ddata[i]);
    break;
case 15: /* ensemble number */
    ens = comb(ddata[i], ddata[i+1]);
    /* printf("ensemble %d = %d\n", ens); */
    break;
case 16: /* built-in test status */
    status_b = comb(2ER08, ddata[i]);
    break;
case 20: /* signal-to-noise threshold */
    snr = comb(2ER08, ddata[i]);
    break;
case 21: /* percent good threshold */
    pgt = comb(2ER08, ddata[i]);
    break;
case 22: /* "pitch" (deg) */
    tilt = DEG*comb(ddata[i], ddata[i+1])/RES_16;
    if (tilt > 180.0)
        tilt = tilt - DEG;
    break;
case 24: /* "roll" (deg) */
    tilt = DEG*comb(ddata[i], ddata[i+1])/RES_16;
    if (tilt > 180.0)
        tilt = tilt - DEG;
    break;
case 26: /* heading (deg) */
    hns = comb(ddata[i], ddata[i+1]);
    head = DEG*((short)hns)/RES_16;
    break;
case 28: /* temperature (deg C) */
    temp = 45. - 50.
        + (int) comb(ddata[i], ddata[i+1]) / RES_12;
    break;
case 30: /* high voltage input (volts) */
    vhi = VLTSC_N*comb(2ER08, ddata[i]);
    break;
case 31: /* transmit current (amps) */
    xlt = AMPSC*comb(2ER08, ddata[i]);
    break;
case 32: /* low voltage input (volts) */
    vlow = VLTSC_L*comb(2ER08, ddata[i]);
    break;
case 35: /* pitch std deviation (deg) */
    std = STCOM*comb(2ER08, ddata[i]);
    break;
case 37: /* roll std deviation (deg) */
    std = STCOM*comb(2ER08, ddata[i]);
    break;
case 39: /* heading std deviation (deg) */
    std = STCOM_N*comb(2ER08, ddata[i]);
    break;
}
}

```

```

stor[irec].ldr[0] = data;
stor[irec].ldr[1] = (float) ablay;
stor[irec].ldr[2] = (float) ens;
stor[irec].ldr[3] = (float) status_by /* bit; */
stor[irec].ldr[4] = tilt;
stor[irec].ldr[5] = tilt;
stor[irec].ldr[6] = head;
stor[irec].ldr[7] = temp;
stor[irec].ldr[8] = vhl;
stor[irec].ldr[9] = mlt;
stor[irec].ldr[10] = vlow;
stor[irec].ldr[11] = ady;
stor[irec].ldr[12] = ady;
stor[irec].ldr[13] = xdy;

```

```

/* err.c
 * The err function is called in dproc and pproc to fill part of a global
 * error variable in the average structure. The average structure holds
 * the output values packed in repack. The status bits in the output
 * stream are calculated here from the % good ADCP data and stored in
 * the average structure also.
 */

#include <stdio.h>
#include <unistd.h>
#include <math.h>

void err(unsigned char arec)
{
    float stat;
    unsigned char i, j, lrec, lbin;
    unsigned char avbin, av, bdcoun;

    /* calculate status bit for each average bin */

    /* initializations */
    av = 0; /* counts the number of bins to be averaged together */
    avbin = 0; /* current avg bin whose status is being calculated */
    bdcoun = 0; /* incremented everytime percent good < 25 is the avg bin */
    /* initialize status bit values in avg structure */
    for (i = 0; i < AVG_BINS; i++)
        avg.ab[i] = 0;
    if (lrec == 0)
        return;

    /* loop for counting percent good < 25 over MBIMA bin, MBICA records and
     * 4 beams (MBZM). If bdcoun >= (MBIMA*arec*MBZM*10) then the status bit
     * for that avg bin is set to 1. */
    for (lbin = 0; lbin < (MBIMA * AVG_BINS); lbin++)
    {
        av = av + 1;
        for (lrec = 0; lrec < arec; lrec++)
        {
            for (i = 0; i < MBZM; i++)
            {
                /* printf(" %.2f", arec[lrec].gd[i] * (lbin)); */
                if (arec[lrec].gd[i] * (lbin) < 25.0)
                    bdcoun = bdcoun + 1;
            }
            /* printf("\n"); */
        }
        if (av == MBIMA)
        {
            /* printf("bdcoun = %d = %.2f ratio\n", bdcoun, ((float)bdcoun/96)); */
        }
    }
}

if (bdcoun >= (10*MBIMA*arec*MBZM))
    avg.ab[avbin] = 1;
else avg.ab[avbin] = 0;
avbin = avbin + 1; /* reset bin counter */
bdcoun = 0; /* increment index for status array */
/* reset good counter */
}

/* set error codes from status byte info stored in leader array */
/* instrument receiver errors from the status byte */
for (lrec = 0; lrec < arec; lrec++)
{
    stat = arec[lrec].lrec;
    if ((lrec < stat) && (stat < 80)) &&
        ((stat < 32) || (stat < 48) || (stat < 64))
    {
        if ((0x01 & avg.error) == 0)
            avg.error |= 1;
    }
}

/* instrument transmitter errors: very low, low and high current */
if ((80 < stat) && (stat < 83))
{
    if ((0x02 & avg.error) == 0)
        avg.error |= 2;
}

```

```

/*
 * function pc_leader.c
 *
 * This routine accepts an array of stored ADCN data set up by
 * function up_1.c and deplatched by pc_dfln.c. Each data
 * type in the leader is averaged over the number of records
 * (ensembles) in the storage array. An averaged data array
 * is filled with the resulting values.
 */
#include <stdio.h>
#include <math.h>
#include "dapro.h"

void pc_leader( unsigned char arcc )
{
    /* arcc is number of records in storage */

    unsigned char lrec;          /* record counter */
    unsigned char j;             /* leader data type index */

    /* Initialize average leader buffer */
    for (j=0; j<MAXLDR; j++)
        avg_ldr[j] = 0.0;

    /* leave function if arcc==0 */
    if (arcc==0)
        return;

    /* loop through each data type in leader */
    for (j = 0; j < MAXLDR; j++)
    {
        /* sum stored records for each data type */
        for (lrec = 0; lrec < arcc; lrec++)
        {
            avg_ldr[j] = avg_ldr[j] + arcc(lrec, ldr[j]);
        }

        /* compute mean */
        avg_ldr[j] = avg_ldr[j] / (float) arcc;
    }
}

```



35

```

/* vel at observed depths */
v0[j] = stor(lrec).vel(lbeam[j]);
/* amplitude at observed depths */
a0[j] = stor(lrec).amp(lbeam[j]);
}

/* do linear interp for v(j) = vel at standard depths,
 * replace vel at obs depths with vel at std depths.
 * do linear interp for a(j) = amp at standard depths,
 * replace amp at obs depths with amp at std depths. */
lerc1 = lincp10, v0, nblm, v, v, nblm, inf, sbl, s, jerr);
if (jerr < (nblm/2))
{
    for (j = 0; j < nblm; j++)
        stor(lrec).vel(lbeam[j]) = v(j);
}
else if ((avg.error < 0.001) == 0)
    avg.error += 0;

lerc2 = lincp10, a0, nblm, v, a, nblm, inf, sbl, s, jerr);
if (jerr < (nblm/2))
{
    for (j = 0; j < nblm; j++)
        stor(lrec).amp(lbeam[j]) = a(j);
}
else if ((avg.error < 0.001) == 0)
    avg.error += 0;
}

/* end translation correction loop */

/* conversion from slant vel to janus vel scales like
 * 4/(2*cos(theta0)) for u, v and 2/(2*sin(theta0)) for w
 * where theta0 = 40 deg is the beam angle from horiz
 * and a = 88/1316 is soundspeed correction factor. */
wscale = SSCOR / (2.0 * CHRT0);
uscale = SSCOR / (2.0 * SINET0);

/* compute janus velocities and do rotation correction */
for (j = 0; j < nblm; j++)
{
    /* combine slant velocities to form janus velocities */
    ju = (double) { wscale *
        (stor(lrec).vel(0[j]) - stor(lrec).vel(11[j])) };
    jw = (double) { wscale *
        (stor(lrec).vel(3[j]) - stor(lrec).vel(21[j])) };
    jv1 = (double) { wscale *
        (stor(lrec).vel(0[j]) + stor(lrec).vel(11[j])) };
    jw2 = (double) { wscale *
        (stor(lrec).vel(21[j]) + stor(lrec).vel(31[j])) };

    /* rotation correction follows AD's conventions for
     * pitch and roll angles, and the implicit assumption
     * that the janus velocities are representative of the
     * component velocities for each beam */
    stor(lrec).vel(0[j]) = (float)
        { ju * cos(rho)
          + jw1 * sin(rho) };
    stor(lrec).vel(11[j]) = (float)
        { jw * cos(phi)

```

```

          + ju * sin(rho) * sin(phi)
          - jw2 * sin(phi) * cos(rho) };
    stor(lrec).vel(21[j]) = (float)
        { jv1 * cos(phi) * cos(rho)
          - ju * sin(rho) * cos(phi)
          + jv * sin(phi) };
    stor(lrec).vel(31[j]) = (float)
        { jw2 * cos(phi) * cos(rho)
          - ju * sin(rho) * cos(phi)
          + jv * sin(phi) };
}

/* correct heading for magnetic declination, correct
 * janus horizontal velocities for heading */
hd = head(lrec) * decl; /* add decl to heading */
arg = (double) { hd * pi / 180.0 };
sinhd = (float) sin(arg); coshd = (float) cos(arg);
for (j = 0; j < nblm; j++)
{
    ju = stor(lrec).vel(0[j]);
    jw = stor(lrec).vel(11[j]);
    stor(lrec).vel(0[j]) = ju * coshd + jw * sinhd;
    stor(lrec).vel(11[j]) = jv * coshd - ju * sinhd;
}

/* display current record
for (lbeam = 0; lbeam < NBEAM; lbeam++) {
    printf(" lrec %d lbeam %d ", lrec, lbeam);
    for (j = 0; j < 5; j++) {
        printf(" %10.4f", stor(lrec).vel(lbeam[j]));
        printf("\n");
    }
}

/* end of record processing loop */

/* echo amplitude processing routine: noise level */
/* estimate "noise level" by averaging last four bins of each
 * beam for all of the stored records */
for (lbeam = 0; lbeam < NBEAM; lbeam++)
{
    nlevel[lbeam] = 0.0;
    for (lrec = 0; lrec < nrec; lrec++) /* 37 use 1 37 */
    {
        for (j = (nblm-4); j < nblm; j++)
        {
            nlevel[lbeam] = nlevel[lbeam] + stor(lrec).amp(lbeam[j]);
        }
        nlevel[lbeam] = nlevel[lbeam] / (float) { 4 * nrec };
    }
}

/* average velocity and echo amplitude routines combined */
/* average janus velocities and amplitudes over records and bins */

```

```

/* Initialize counters, start loop */
k = 0;
ibin = 0;
for (j = 0; j < (NBINA * AVERAGE); j++)
{
    ibin = ibin + 1;

    /* average over stored records for this depth bin */
    for (irec = 0; irec < nrec; irec++)
    {
        /* Janus east velocity */
        avg_jan0[k] = avg_jan0[k] + stor[irec].vel[0][j];
        /* Janus north velocity */
        avg_jan1[k] = avg_jan1[k] + stor[irec].vel[1][j];
        /* Janus vertical vel. */
        avg_jan2[k] = avg_jan2[k] + stor[irec].vel[2][j];

        /* average over beams as well as records for
        amplitude average of this depth bin */
        for (lbeam = 0; lbeam < NBZAW; lbeam++)
        {
            avg_amp[k] = avg_amp[k] + stor[irec].amp[lbeam][j];
        }

        /* compute the average velocities */
        avg_jan0[k] = avg_jan0[k] / (float) (nrec*ibin);
        avg_jan1[k] = avg_jan1[k] / (float) (nrec*ibin);
        avg_jan2[k] = avg_jan2[k] / (float) (nrec*ibin);

        /* compute the average amplitude */
        avg_amp[k] = avg_amp[k] / (float) (nrec*ibin*NBZAW);

        /* reset counters */
        ibin = 0;
        k = k + 1;

        /* end of bin loop for velocities and amplitudes */
    }
}

```





```

/* f to_m converts float variable passed to function into an unsigned char
 * with the four bit value packed in the least significant nibble of
 * the byte.
 * 7 is added to the value of the float.
 * If the float is < -7 then -7 is returned, if > 8 then 8 is returned.
 * The float is rounded; fractions between .45 and .55 are rounded to
 * the nearest even integer.
 */
unsigned char f_to_m (float f0)
{
    int round (float f);
    f0 = round(f0);
    if (f0 < -7)
        f0 = -7;
    if (f0 > 8)
        f0 = 8;
    return (unsigned char) (f0 + 7);
}

/* round function converts float to int and rounds the value to the next
 * larger absolute value integer if the fractional component is > 0.50,
 * smaller absolute value integer if the fractional component is < 0.50
 * If the fraction = .50 then it is rounded to the closest even integer
 */
int round (float f)
{
    float t;
    t = f - (int) f;
    if (fabs(t) < 0.50)
        return (int) f;
    if (t > .5)
        return (int) (f+1);
    if (t < -0.50)
        return (int) (f-1);
    if (((int) f & 2) == 0) /* if int of f is even */
        return (int) f;
    else return (int) (f+1); /* when int of f is odd add 1 */
}

if (t < -.50)
    return (int) (f-1);
if (t == -.50)
{
    if (((int) f & 2) == 0) /* if int of f is even number */
        return (int) f;
    else return (int) (f-1); /* when int of f is odd */
}

/* C_hex changes the signed and unsigned char in output array into hex
 * values in the least significant nibble of the unsigned char it returns
 * The steps in the routine are:
 * 1: checks to see that the most sig nibble is zero, returns an error flag

```

```

/* pow.c */
/* by Robin Singer January 1991 */
/* used pow to avoid conflict with gc library function pow */
/* added to acp code because Franklin C does not have pow function */
/* pow raises the base to the ath power */
/* it is assumed that a>=0 */
/* param: a declared as a double to be consistent with MSC but a really */
/* needs to be an integer for this function to work */

double ppow(double base, double a)
{
    double p;
    int i;

    p=1.0;
    for(i=1; i<=(int)a; i++)
        p=p*base;
    return p;
}

/* takes one byte and returns the most and least significant 4 bits (1 nibble) */
/* packed into an unsigned byte with leftmost digits zero filled */
splitb(byte, lsb, msb)
    unsigned char byt, *lsb, *msb;
{
    *lsb = byt & 017;
    *msb = (byt & ~017) >> 4;
    return;
}

```

```

/* takes an unsigned short integer, determines if it is greater than 2047
and generates a signed integer by wrapping the 12 bit value */
short signb(ival)
unsigned short ival;
{
    short i;
    if ( ival > 2047)
        i = ival - 4096;
    else
        i = ival;
    return(i);
}

```

```

/* takes two bytes and packs them into an unsigned 16 bit integer which is
returned */
unsigned int comb(lab,mab)
unsigned char lab,mab;
{
    return (((unsigned int)lab << 8) | mab);
}

```

```

/* The function comba combines 1 byte and 1 nibble into an unsigned
16 bit integer
if "which" is zero, the nibble lives in the high order bits
else nibble lives in the lowest four bits
*/

```

```

/* modified by rcs for use with Franklin C v 3.07 */
unsigned short comba(int which, unsigned char by, unsigned char nibble)

```

```

{
    if (!which)
        return(((unsigned int)nibble << 8) | by);
    else
        return(((unsigned int)by << 4) | nibble);
}

```

```

/* this routine returns the Julian day associated with a month, day and year */
int julian(m,d,y)

```

```

int m;
int d;
int y;

```

```

{
    int j;
    switch(m) {
        case 1: j = d; break;
        case 2: j = d + 31; break;
        case 3: j = d + 59; break;
        case 4: j = d + 90; break;
        case 5: j = d + 120; break;
        case 6: j = d + 151; break;
        case 7: j = d + 181; break;
        case 8: j = d + 212; break;
        case 9: j = d + 243; break;
        case 10: j = d + 273; break;
        case 11: j = d + 304; break;
        case 12: j = d + 334; break;
        default: j = -1; break;
    }
    if (y & 4 == 0 && m > 2)
        j = j + 1;
    return(j);
}

```





```

curtime-localtime(&bttime); /* convert to local time */
timeptr = li(&actime(&curtime)); /* assign ptr to pt at hour */
strcpy(minute, timeptr);
now-atol(minute);
if(((now-hour) < (now-00-past)) || ((now-past) < (now-min)))
    yes = TRUE; /* minute minutes has passed */
}

```

```

/* TFC */
/* May 17, 1991 */
/* by Robin C. Singer */

/* Tactile Emulation Program */
/* Addressing the DPM by alternating between the two addresses */
/* with an offload command, at a user selectable interval. */
/* Receiving and displaying the data send back by the DPM. */

#define FALSE 0
#define TRUE 1

#include <stdio.h>
#include <graph.h>
#include <conio.h>
#include <time.h>
#include <stdlib.h>
#include <bios.h>
#include <sys/types.h>
#include <unistd.h>

int getch(void);

int ensemble, intchar, n, status, div, at, nummin, altflag;
char fnstr[25];
unsigned char blachar;

FILE *fp, *fpp;

void initline(void);
void sendcmd(int flag);
void waitmin(void);
void getdata(void);

main()
{
    clrscr();
    status = asopen(CON, LIBOUT|BINARY|NORMAL, 100, 100, 5000, 5, 0, 1, 1);
    if(status < 0) return;
    printf("Port not open. status = %d\n", status);
    exit(1);
    printf("\n\nEnter name of output .dat file ");
    scanf("%s", fnstr);
    if(!fopen(fnstr, "w")) return; /* create it */
    printf("Error opening %s\n", fnstr);
    printf("\n\nHow many minutes between addresses? ", nummin);
    scanf("%d", &nummin);
    printf("\n\nWaiting for the 60 second");
    printf("\n\nThen sending an address and offload command every 60 minutes, nummin");
    printf("\n\nType a 'Q' to end.\n");
    exit(FALSE);
    initline();
    while(!exit_)
    {
        altflag = !altflag;

```

```

yet = FALSE;
while(!yet)
{
    time(&btctime); /* time in second since midnite 1/1/70 GMT */
    curtime=localtime(&btctime); /* ~convert to local time */
    tmpr = localtime(&curtime); /* assign ptr to pt at hour */
    atemp=(tmpr->tm_mon+1);
    now=atol(tmpr->tm_mon);
    if((now>minmin)&&(now<60-past)--nummin); /* (now-past)<nummin */
    yet = TRUE; /* numin minutes has passed */
    if(now==past)
    {
        flag = TRUE;
        chit = 0;
        if(!bkeybd(KEYBD_READY))
        {
            chit = bkeybd(KEYBD_READ)+OFF;
            if(((char)chit=='Q')||((char)chit=='0'))
            {
                exit = TRUE;
                yet = TRUE;
            }
        }
    }
}

```

```

}
}

```

```

void sendcmd(int flag)
{

```

```

    st--;
    while(st)
    {
        st--(asiputc(COM1,'0'));
        st--;
        while(st)
        {
            st--(asiputc(COM1,'0'));
            if(flag)
            {
                while(st)
                {
                    st--(asiputc(COM1,'0'));
                }
            }
            else
            {
                while(st)
                {
                    st--(asiputc(COM1,'1'));
                }
            }
            while(st)
            {
                st--(asiputc(COM1,'1'));
            }
        }
    }

```

```

}
void getdata(void)
{

```

```

    int c,n,cont;
    printf("\n");
    for(n=1;n<=30;n++)
    {
        cont=TRUE;
        while(cont)
        {
            c=asiputc(COM1);

```

```

        if(c>=ASUCCESS)
        {
            putc(c,&stdout);
            putc(c,&fpp);
            cont=FALSE;
        }
    }
    fprintf(fpp,"%s");
}

```

## D. Technical information

The layout of the principal DPM board components, including the specially made DPM component carriers, is shown in Figure 11. The DPM board schematic is shown in Figure 12. DPM mechanical and electrical specifications are provided in Table 1. Connector specifications for the DPM and cable specifications for the DPM to ADCM interconnection are given in Table 2. A parts list is provided in Table 3.

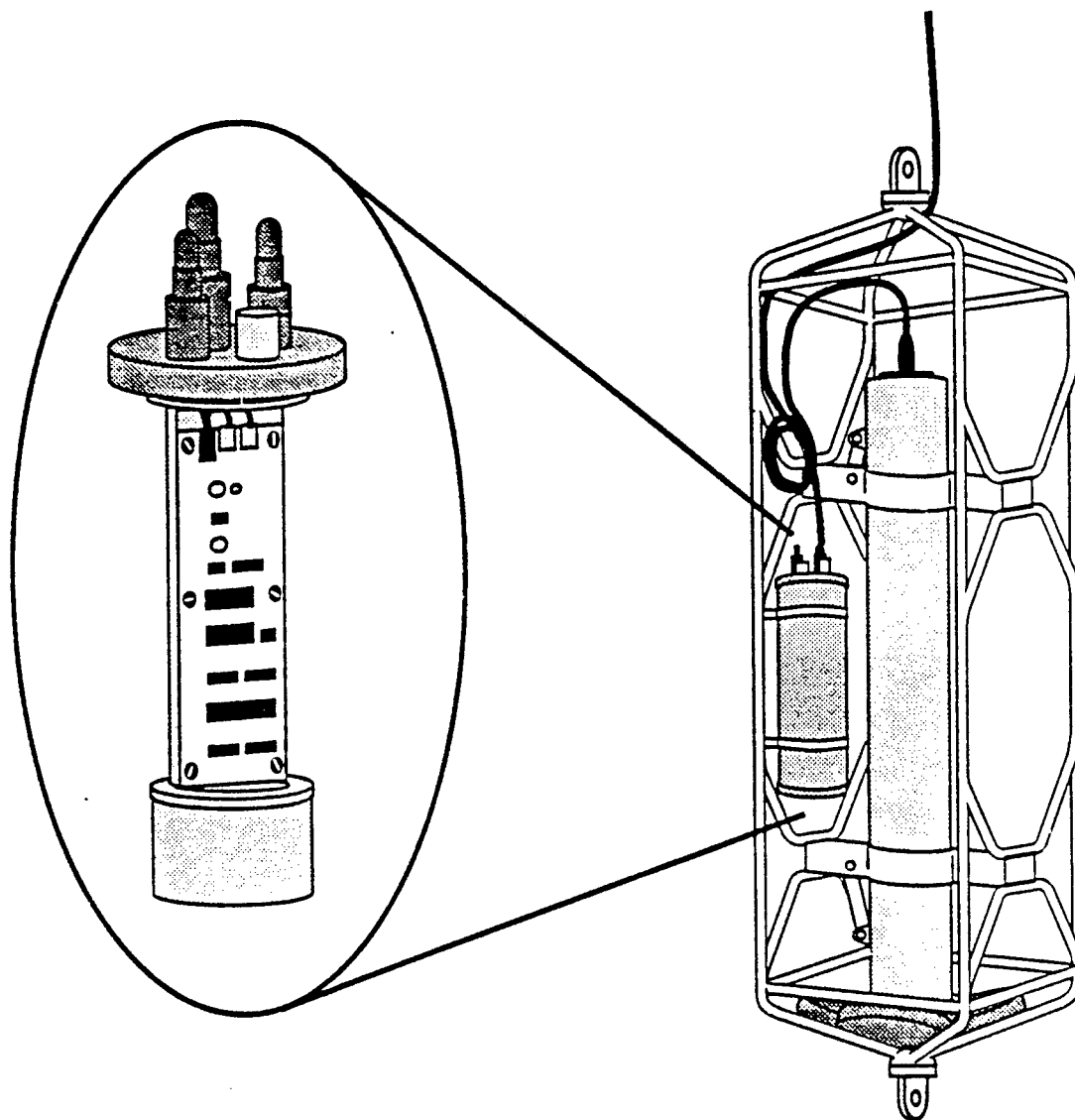


Figure 1: The Data Processing Module (DPM) is a self-powered unit in its own pressure case designed to be deployed along with an RD Instruments Acoustic Doppler Current Meter (ADCM). The figure shows a typical deployment configuration with the DPM clamped onto the ADCM load cage. Inside the DPM pressure case is a single-board electronics package and two battery packs (inset). The DPM serves as an interface between the ADCM and a satellite telemetry controller.

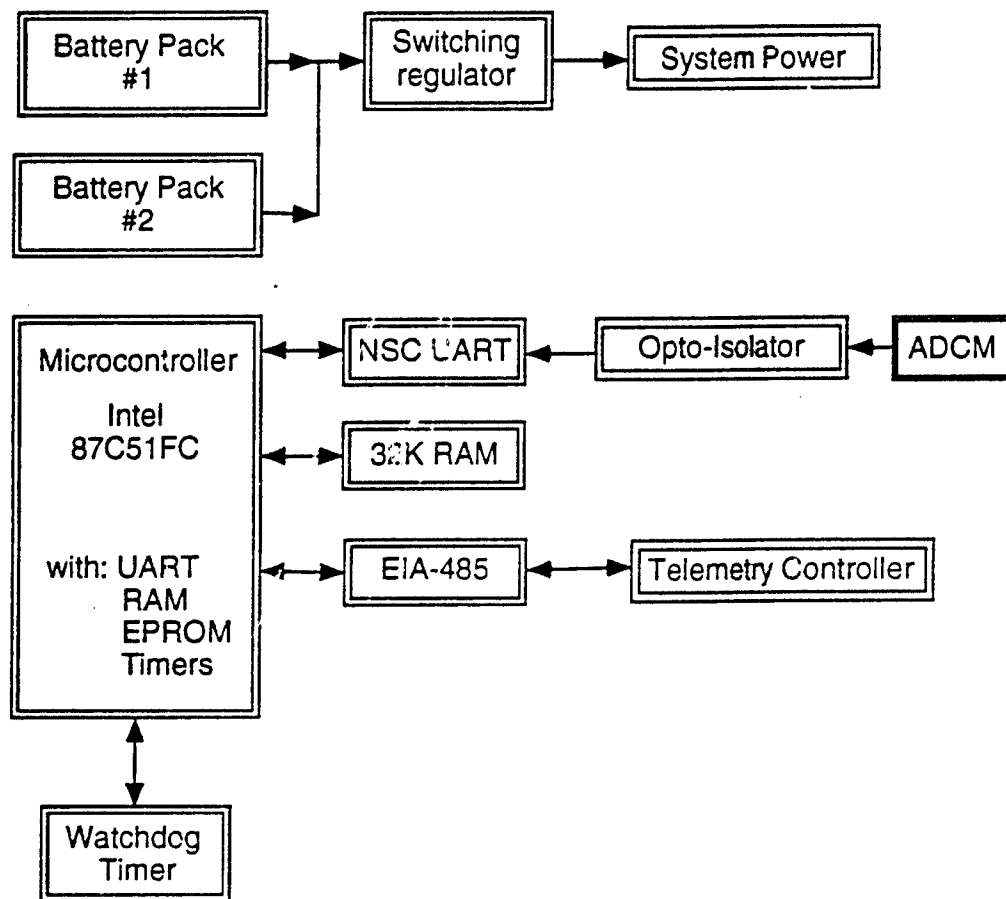


Figure 2: A block diagram of the principal DPM hardware components is shown. The power system consists of two battery packs and a switching regulator. The heart of the electronics is an Intel 87C51FC microcontroller with an onboard UART, 256 bytes of RAM, 32 kbytes of EPROM, and three 16-bit timers. Additional memory is provided by an external 32 kbyte RAM chip. The onboard UART is used for EIA-485 communications to the telemetry controller while an external UART talks to the ADCM through an opto-isolator. A watchdog timer circuit is used to reset the microcontroller in the event of software or communication errors.

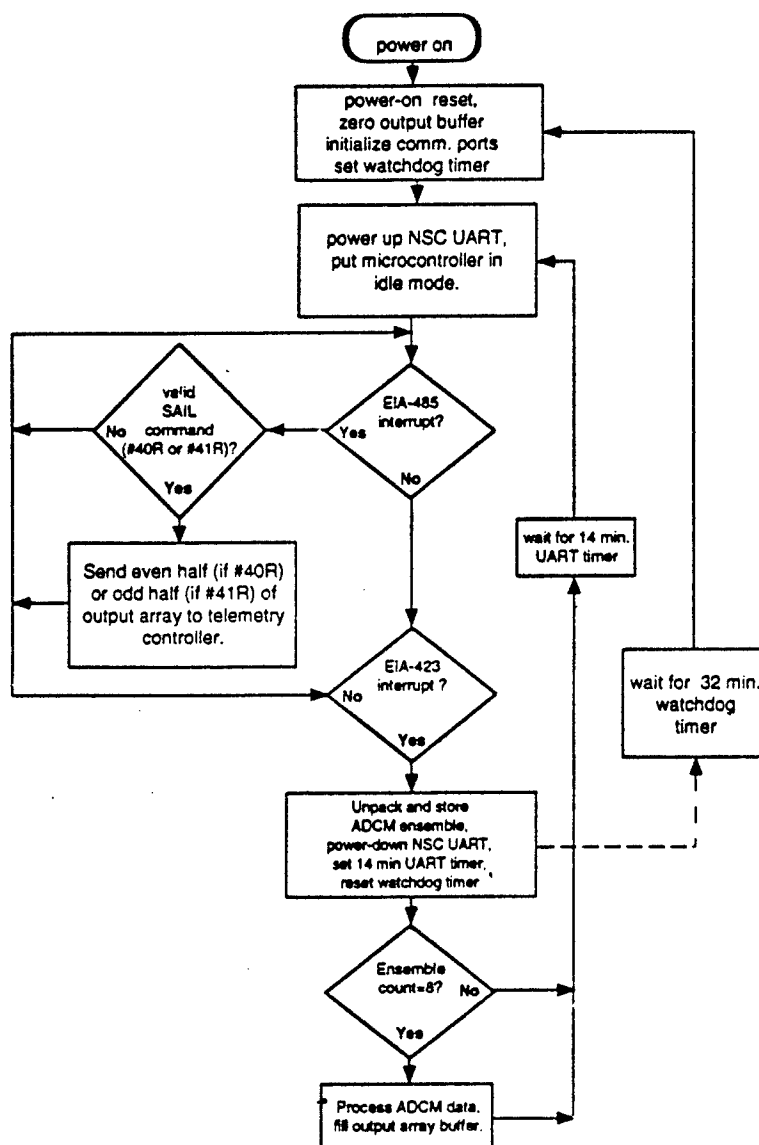


Figure 3: The main control loops of the DPM processing program and the response to communication interrupts are shown in a flow chart. After initialization, the DPM waits for either an EIA-485 interrupt from the telemetry controller or an EIA-423 interrupt from the ADCM. A SAIL data offload command received on the EIA-485 channel initiates the data offload sequence. A valid data stream received through the EIA-423 channel initiates the processing sequence. DPM communication and control are described in more detail in the text.

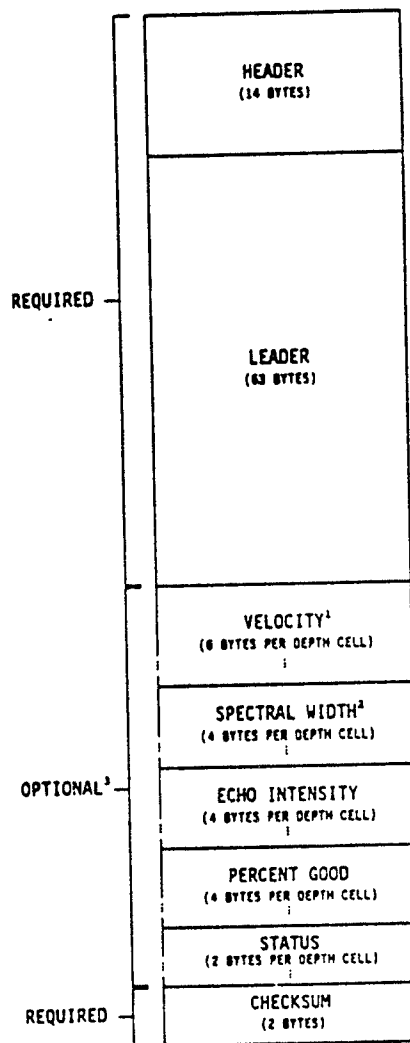


Figure 4: A schematic diagram shows the packed binary data stream transmitted through the ADCM serial I/O connector for each ensemble. The data stream consists of a header, a leader, up to four data arrays, and a checksum. For the implementation of the DPM on the Ice-Ocean Environmental Buoy (IOEB), the data stream is 719 bytes long and the data arrays selected are velocity, echo intensity, percent good, and status. The DPM decodes the variables from each ensemble and stores them in RAM. After eight ensembles have been accumulated, the processing sequence is initiated.

		BIT POSITIONS									
		7	6	5	4	3	2	1	0		
B Y T E  N U M B E R	1	OUTPUT DATA BUFFER SIZE								MSB	
	2									LSB	
	3	LEADER DATA BUFFER SIZE								MSB	
	4									LSB	
	5	VELOCITY DATA BUFFER SIZE								MSB	
	6									LSB	
	7	SPECTRAL WIDTH DATA BUFFER SIZE								MSB	
	8									LSB	
	9	ECHO INTENSITY DATA BUFFER SIZE								MSB	
	10									LSB	
	11	PERCENT-GOOD DATA BUFFER SIZE								MSB	
	12									LSB	
	13	STATUS DATA BUFFER SIZE								MSB	
	14									LSB	

Figure 5: The contents of the ADCM header are shown. The data array sizes transmitted in the header are compared to the expected array sizes based on the ADCM configuration. Since the array sizes are fixed after the initial configuration, this comparison serves as a check of the integrity of the incoming data stream.

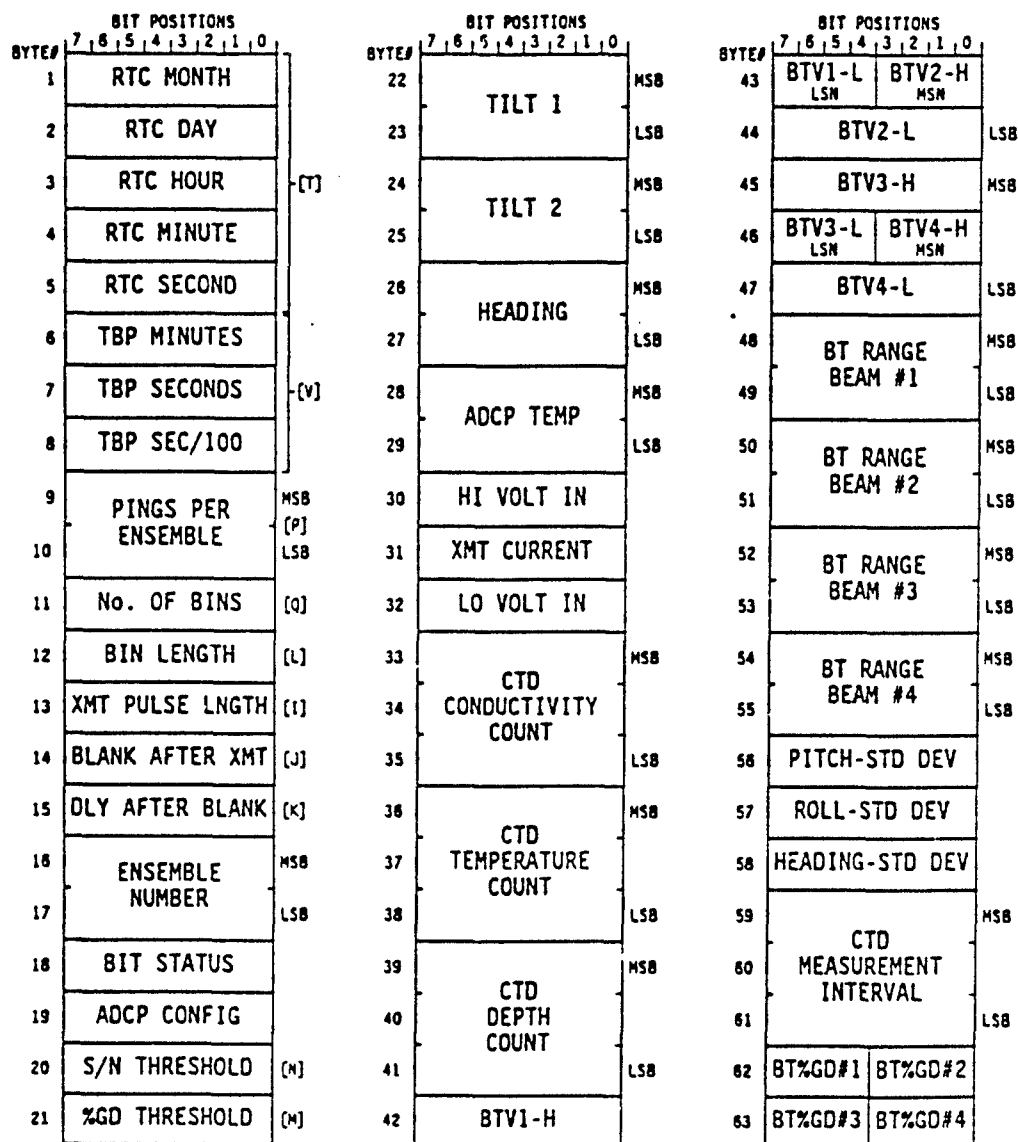


Figure 6: The contents of the ADCM leader are shown. All leader data except that related to CTD sampling and bottom tracking (neither of which are implemented) are decoded and stored in RAM. Some data (e.g., number of bins, BIT status) are used in error checking. Other data (e.g., heading and tilt) are used during processing.

PTTa

001	010	011	100	101	110
MET & MECH SENSORS (87)	ST SEACAT I (32)	MET & MECH SENSORS (89)	WTS SEACAT II (32)	MET & MECH SENSORS (95)	S4 (38)
ITIME (14)	ADCP (135)	ECHO (12)	ADCP (135)	PTTa (6)	ADCP (135)
ICE STRESS (42)		ICE STRESS (42)		ICE STRESS (42)	
ICE THERMS (110)	SEACAT & DO, FL (56)	ICE THERMS II (110)	SEACAT & DO, FL (56)	ICE THERMS III (110)	SEACAT & DO, FL (56)
	TRANS/FL (24)		TRANS/FL (24)		TRANS/FL (24)

PTTb

100	101	110	001	010	011
WTS SEACAT II (32)	MET & MECH SENSORS (95)	S4 (38)	MET & MECH SENSORS (87)	ST SEACAT I (32)	MET & MECH SENSORS (89)
ADCP (135)	PTTb (6)	ADCP (135)	ITIME (14)	ADCP (135)	ECHO (12)
	ICE STRESS (42)		ICE STRESS (42)		ICE STRESS (42)
SEACAT & DO, FL (56)	ICE THERMS III (110)	SEACAT & DO, FL (56)	ICE THERMS (110)	SEACAT & DO, FL (56)	ICE THERMS II (110)
TRANS/FL (24)		TRANS/FL (24)		TRANS/FL (24)	

Schedule Hour 1 Hour 2 Hour 3 Hour 4 Hour 5 Hour 6

Figure 7: The transmission scheme for the IOEB Argos telemetry system is shown. Two PTTs are used to transmit data from various sensors. The two PTT controllers, each using a different SAIL address, interrogate the DPM at two hour intervals to request ADCM data. The DPM sends the even-bin data in response to one of the SAIL addresses, and the odd-bin data in response to the other. Since the two-hour PTT transmission intervals are staggered by one hour, the DPM is interrogated twice over a two hour interval (once by each PTT) and the full output array is transmitted in two halves.

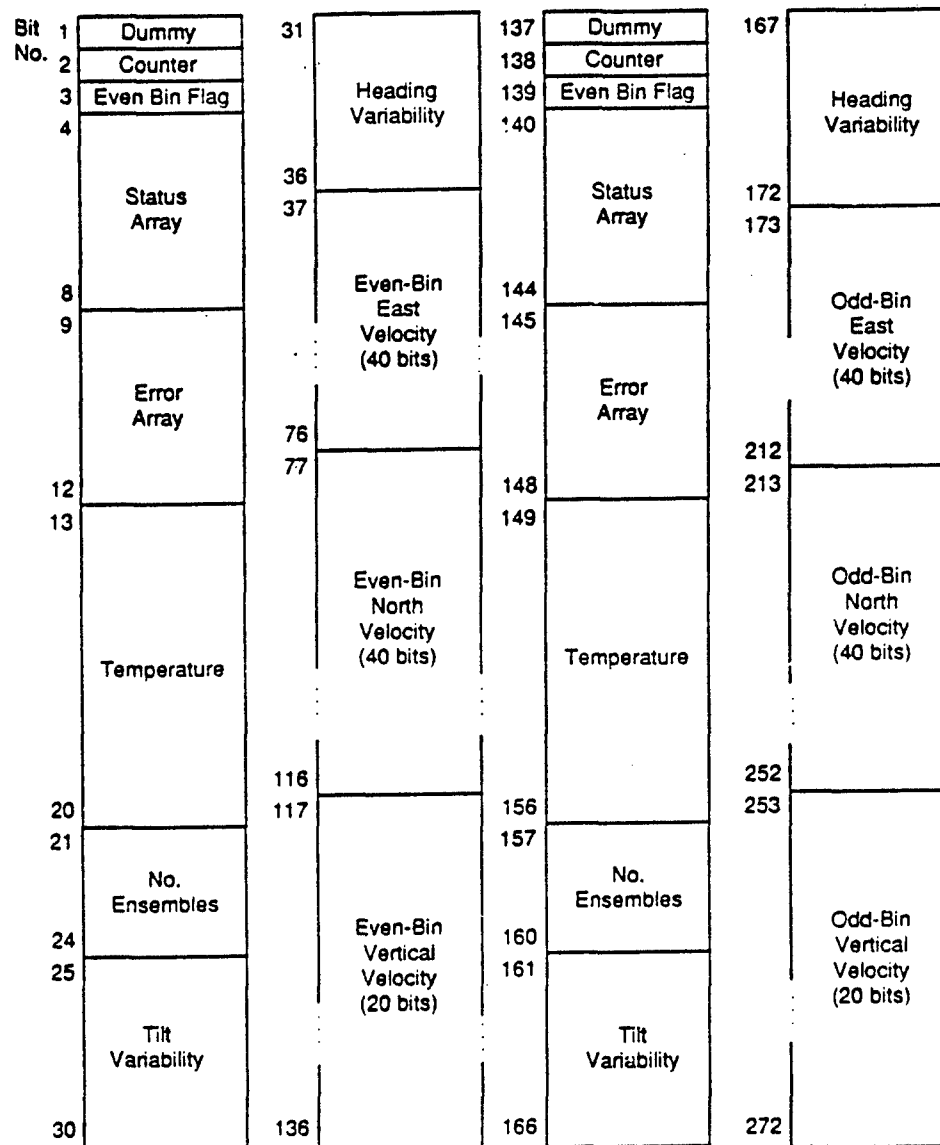


Figure 8: The contents of the DPM output array are shown. The output array is sent in two 136 bit halves in response to interrogation by two different PTT controllers (see Fig. 7). The dummy bit is stripped off by the telemetry controller to give a 135 bit sequence for transmission. The values of the error array, temperature, number of ensembles, tilt variability and heading variability are the same for both halves of the array.

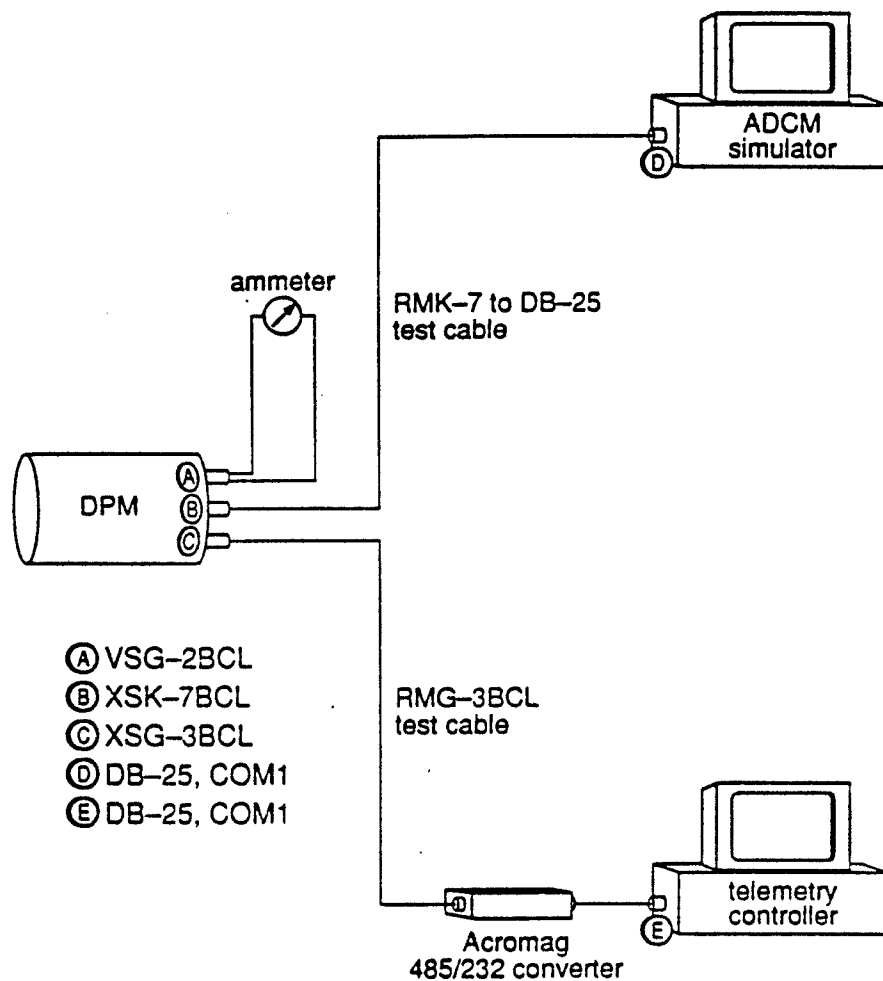


Figure 9: A schematic of the DPM test configuration, including two IBM compatible PCs, an ammeter, and various test cables, is shown. The ammeter replaces the DPM shorting plug and is used to check current draw by the UART and microcontroller. The PCs simulate the ADCM and telemetry controller. The ADCM simulator sends a sequence of data ensembles designed to test a variety of DPM error checking features to the DPM. The telemetry simulator interrogates the DPM and records the output. The output from a test run can be compared to the desired results to confirm proper operation.

Figure 10: The expected output arrays from a DPM test run using the configuration shown in Fig. 9 and the data file DPMCCS6.BIN as input to the OVERNITE.C program are shown. Each line represents the response of the DPM to an interrogation from the PC simulating the telemetry controller. Over a 36 hr interval the 144 ensembles in DPMCCS6.BIN are processed into 18 output arrays (there are 36 lines since the array is output one half at a time).

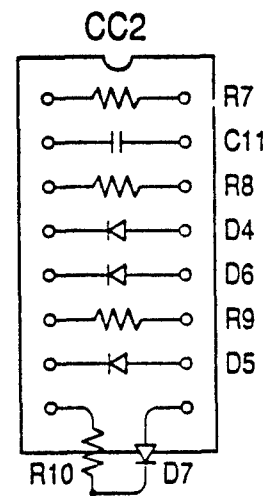
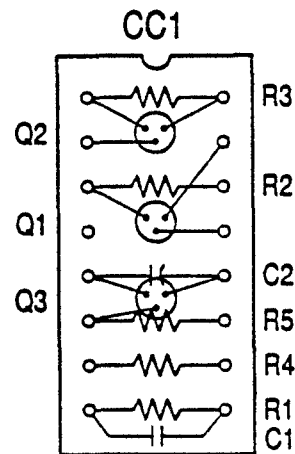
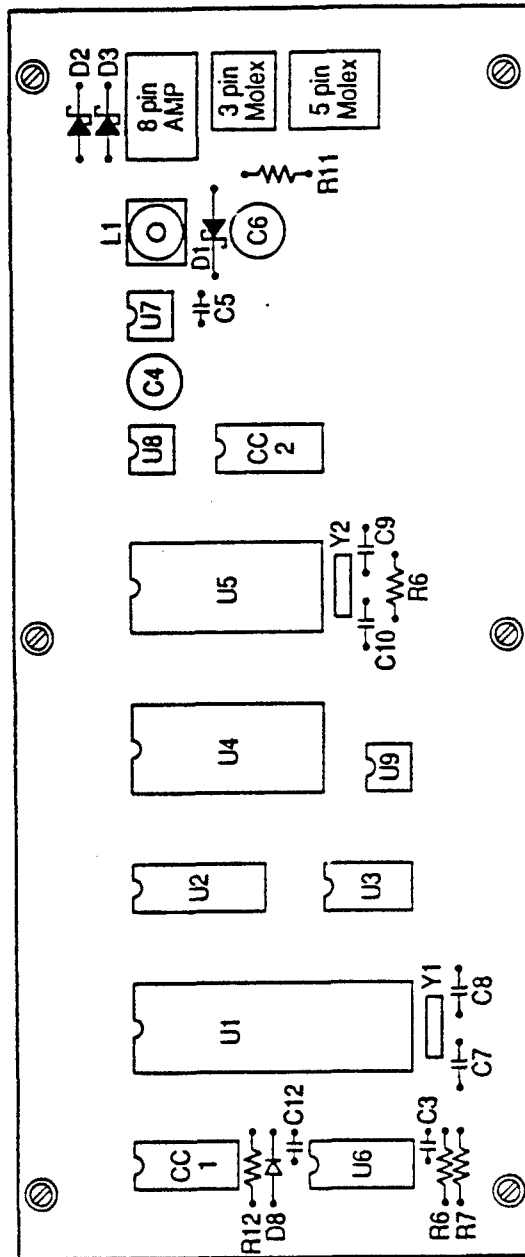


Figure 11: The layout of the DPM processor board is shown. Component identification can be made by referring to Figure 12 and Table 3. The layouts of the component carriers CC1 and CC2 are shown in detail.

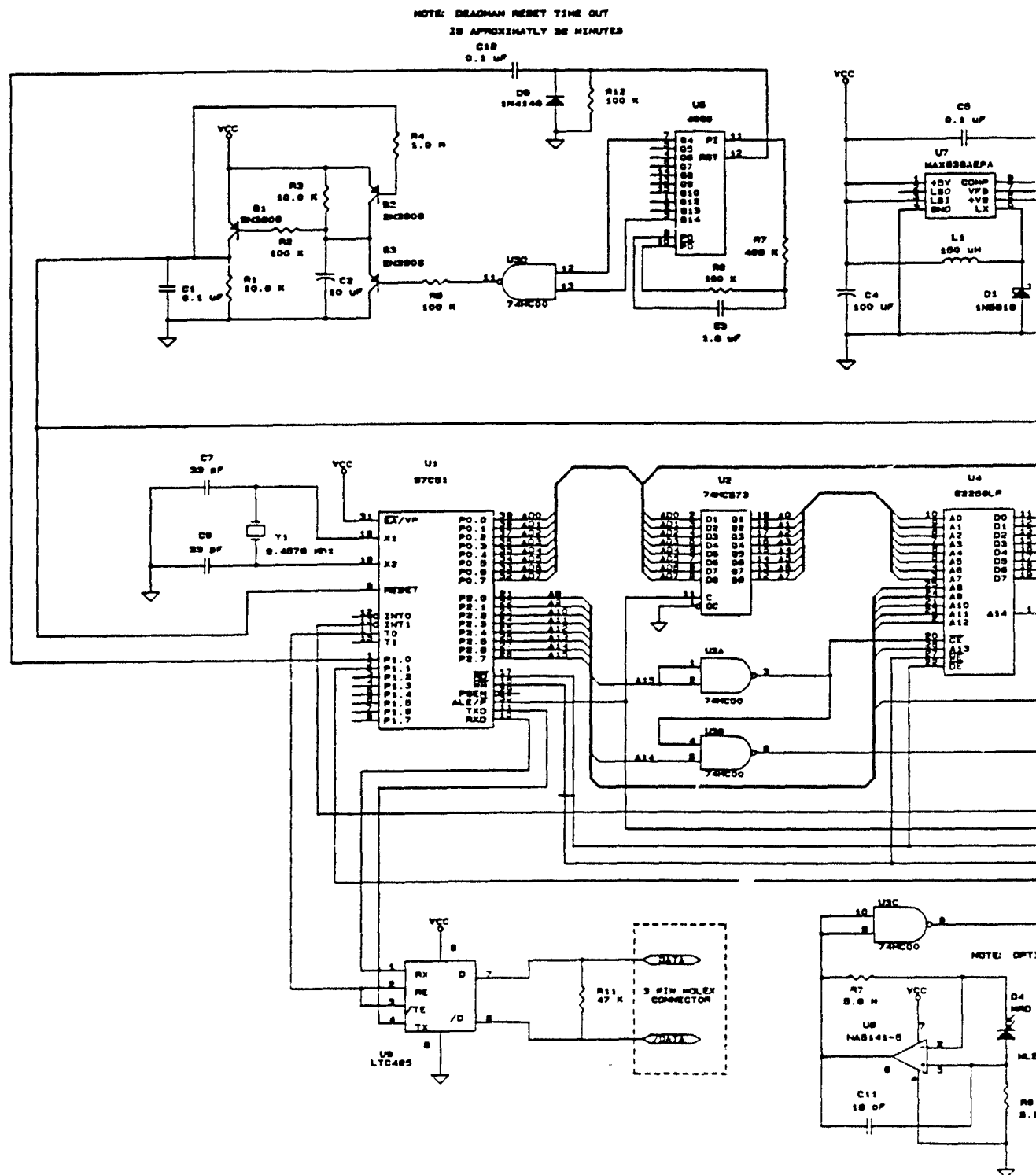
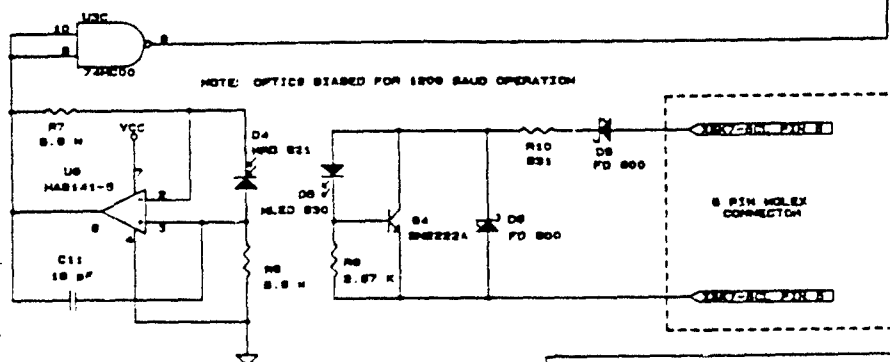
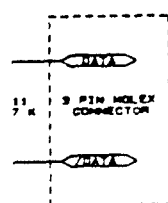
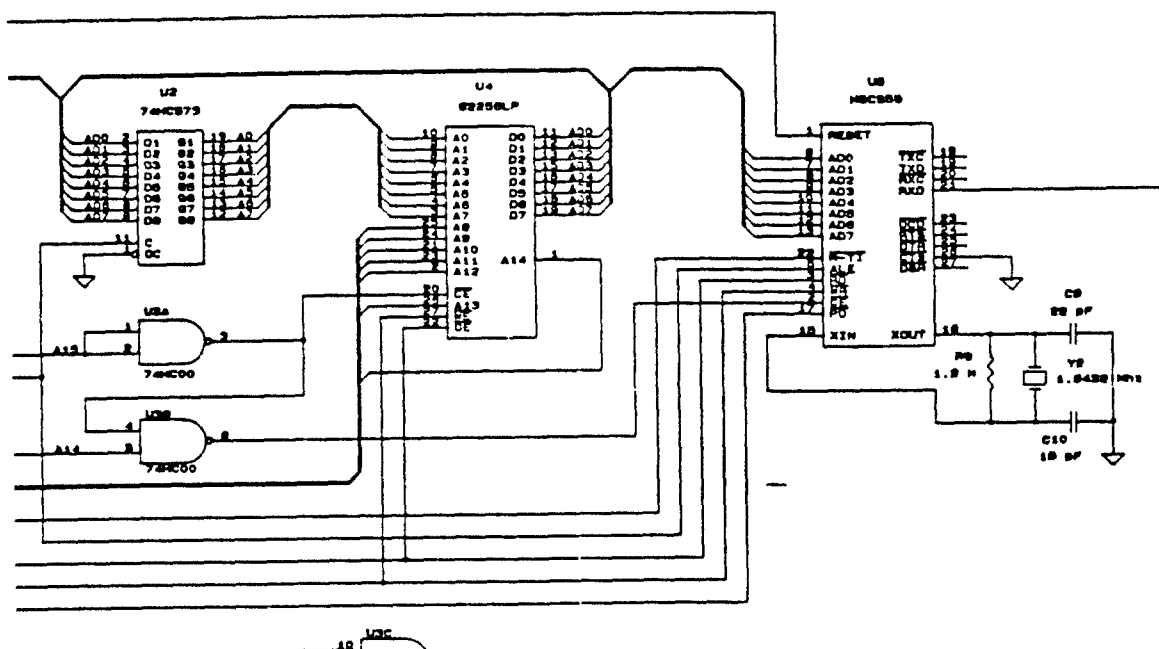
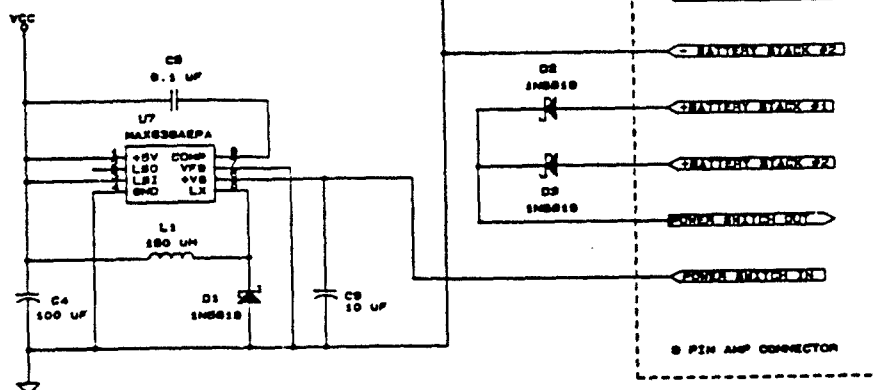


Figure 12: Schematic drawing of the DPM processor board.



2

WOODS HOLE OCEANOGRAPHIC INSTITUTION	
WOODS HOLE, MA. 02543	
Title	
ADCP DATA PROCESSING MODULE	
Size	Document Number
C	OPN.BCH
Date	
August 8 1981	

**Table 1: DPM specifications**

12 July 1991

**Mechanical:**

Housing Material	- 6061-T6 Aluminum Alloy
	- Hardcoated, Anode protected
Weight in air	- 13 kg
Weight in water	- 6.6 kg
*Length	- 50.5 cm
Diameter (end caps)	- 14.6 cm
(housing)	- 14 cm
Electrical penetrators	- 3
(VSG-2BCL)	- (1 each)
(XSG-3BCL)	- (1 each)
(XSK-7BCL)	- (1 each)
Pressure Rating	- 5000 db

**Electrical:**

Avg. power consumption	- 15 mW
Battery capacity	- 28 Ah @ 10.5 VDC
	(Alkaline)
Controller	- Intel 87C51FC
EPROM (Internal)	- 32 k
RAM (Internal)	- 256 Bytes
(External)	- 32 k
COM. Ports	- 2
(EIA - 485)	- (1 each)
** (EIA - 423)	- (1 each)

**Features:**

- Watchdog Reset
- Isolated EIA 423 Port
- Addressable
- Low power consumption
- Environmentally tested  
from 50 to -30 deg. C

\* Length with connectors mated, includes anodes

\*\* Optically isolated, configured for Simplex operation

**Table 2: DPM connector & cable specifications**

**Manufacturer** : Brantner & Associates Inc.  
1240 Vernon Way  
El Cajon, CA 92020-1874

**DPM Connectors**

**Bulkhead Connectors** : XSK-7BCL, 1 each (for EIA-423 port)  
: XSL-3BCL, 1 each (for EIA-485 port)  
: VSG-2BCL, 1 each (for power switch)

**Dummy connector (for shipping)** : RMK-7-FSD w/locking sleeve K-FSL-P  
: RMG-3-FSD w/locking sleeve G-FSL-P  
: VMG-2-FSD w/locking sleeve G-FSL-P

**Shorting connector** : Specified as VMG-2-FSD with Pins #  
1 and 2 Electrically connected, used  
with locking sleeve P/N G-FSL-P

**ADCP - DPM Interconnecting Cable Assembly**

**Cable Terminations** : XSL-20CCP  
: RMK-7FS (with locking sleeve p/n K-FSL-P)

**Cable Length** : 2 meters

**Cable material** : 18/7-SO (7 conductor, #18 AWG copper wire,  
rubber insulated, with neoprene outer jacket)

**Pressure Rating** : 20,000 psi (mated)

**Cable Wiring** :

XSL-20CCP Pin#	XSK-7FS Pin#
2	7
4	6
5	5
13	4
14	3
15	2
16	1

### Table 3: DPM parts list

**ADCP DATA PROCESSING MODULE    Revised: 12 July 1991**  
**Bill of Materials**

Item	Quantity	Reference	Part
1	3	C1,C5,C12	0.1 uF
2	2	C2,C6	10 uF
3	1	C3	1.0 uF
4	1	C4	100 uF
5	2	C7,C8	33 pF
6	1	C9	22 pF
7	2	C10,C11	18 pF
8	3	D1,D2,D3	1N5818
9	1	D4	MRD 821
10	1	D5	MLED 930
11	2	D6,D9	FD600
12	1	D8	1N4148
* 13	1	L1	150 uH
14	3	Q1,Q2,Q3	2N3906
15	1	Q4	2N2222A
16	2	R1,R3	10.0 K
17	4	R2,R5,R6,R12	100 K
18	1	R4	1.0 M
19	1	R6	1.2 M
20	1	R7	499 K
21	2	R7,R8	5.6 M
22	1	R9	2.67 K
23	1	R10	931
24	1	R11	47 K
25	1	U1	87C51FC
26	1	U2	74HC573
27	1	U3	74HC00
28	1	U4	HM62256LP-15
29	1	U5	NSC858N-4I
30	1	U6	74HC4060
31	1	U7	MAX638AEPA
32	1	U8	HA5141-5
33	1	U9	LTC485IJ8
34	1	Y1	2.4576 Mhz
35	1	Y2	1.8432 Mhz

\* L1 was constructed by using 39 turns of #30 AWG enamel wire and a Magnetics Inc. P/N 1107CA100-3B7 ferrite core.

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<b>16. Abstract (Limit: 200 words)</b>  This report describes the development of a Data Processing Module (DPM) designed for use with an RD Instruments Acoustic Doppler Current Meter (ADCM). The DPM is a self-powered unit in its own pressure case and its use requires no modification to the current meter. The motivation for this work was the desire for real-time monitoring and data transmission from an ADCM deployed at a remote site. The DPM serves as an interface between the ADCM and a satellite telemetry package consisting of a controller, an Argos Platform Transmit Terminal, and an antenna. The DPM accepts the data stream from the ADCM, processes the data, and sends out the processed data upon request from the telemetry controller. The output of the ADCM is processed by eliminating unnecessary data, combining quality control information into a small number of summary parameters, and averaging the remaining data in depth and time. For the implementation described here, eight data records of 719 bytes each, output from the ADCM at 15 minute intervals, were processed and averaged over 2 hr intervals to produce a 34 byte output array.			
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